The effect of response measures to climate change on South Africa's economy and trade

MEAGAN JOOSTE, HARALD WINKLER, DIRK VAN SEVENTER AND TRUONG P TRUONG

Final Report
to the Department of Environmental Affairs

The views and options expressed in this paper are those of the consultants and do not represent the views and/or opinions of the Government of the Republic of South Africa, the Department of Environmental Affairs and Tourism, its managers, officials or representatives in any way whatsoever.

December 2009
ENERGY RESEARCH CENTRE
University of Cape Town

Executive summary

Introduction

Article 4.8 of the United Nations Framework Convention on Climate Change (UNFCCC) provides that 'Parties shall give full consideration to … the impact of the implementation of response measures, especially on … (h) Countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products'. Article 2.3 of the Kyoto Protocol to the UNFCCC requires that developed country Parties (Annex I) 'shall strive to implement policies and measures … in such a way to minimize … effects on international trade' as well as minimizing the adverse effects on developing country Parties (Article 3.14). If Annex I Parties implement mitigation, they are assumed to buy less oil, coal or other fossil fuels.

In this context, response measures are actions taken or initiated by developed countries (Annex 1) but with the impacts and ramifications flowing on to developing countries. The concern of developing countries, therefore, is in those impacts which to a greater or lesser extent depend on the degree of exposure of developing countries to trade (with or without the implementation of corresponding climate measures within the developing countries themselves). The South African economy derives much of its growth from production related to the energy-intensive sectors of its economy. In general, with the climate negotiations on the future of the climate regime post-2012, the implications for energy-intensive and trade-exposed sectors of the economy need to be clearly understood.

This research confirms findings of previous studies (see Section 1.3), that the impacts of response measures may imply losses of exports in some sectors, but also possibly gains in other sectors. In this report the scenarios examined are broader than those examined under an earlier Fund of Research into Industrial Development, Growth and Equity (FRIDGE) study. In particular, this study highlights the impacts which response measures have on sectors other than the manufacturing sector, including mining, agriculture and tourism. The present report has provided a more specific identification of energy-intensive and trade-intensive sectors – and those that are both energy- and trade-intensive. We have also examined variations related to scenarios with and without emission trading among Annex I countries, and extended this to the consideration of a no-lose crediting approach for non-Annex I (NAI) countries.

Identifying trade-exposed and energy-intensive sectors

Analysis of trade-exposed sectors finds that industries that are most trade-intensive are not only mining and heavy industries but include other more diversified industries such as basic metals, chemicals, machinery and transport equipment. Descriptive analyses are conducted at the commodity level and at the industry level. At the commodity level there is some limited evidence that South Africa's merchandise export trends are moving away from traditional export clusters in the resources towards higher-added-value clusters such as machinery, transport and other equipment. However, in terms of global trade it would appear that more conventional commodities trade (of minerals) has made something of a comeback on the back of rapid economic expansion in Asia. Thus, although at the industry level the overriding observation remains that resources and related activities such as basic metals and basic chemicals are the key driver of South African exports, diversification into value-added activities such as machinery and transport equipment is noticeable. Agriculture's exports, however, seem to have become more important, while those of processed food have lost ground. This is an interesting trend in that it suggests a reversing of the beneficiation process that may to a larger degree be taking place in the minerals resources complex.

When an expanded view of 'trade exposure' is considered which includes not only direct but also indirect intermediate imports, analysis still identifies the list of 'usual suspect' sectors in terms of trade exposure, as shown in the table below. South Africa's tertiary industries remain less exposed to trade. So, despite some tentative signs of diversification, resource-intensive sectors remain important to exports and are trade-exposed.

No.	*Trade-exposed*	*Energy-intensive*	*Energy-intensive and trade-exposed*
1.	Mining, basic metals (ferrous and non-ferrous metals)	Basic metals (iron and steel and non-ferrous metals)	Basic iron and steel
2.	Machinery	Non-metallic minerals	Non-ferrous metals
3.	Chemicals	Chemical and petrochemical products	Chemicals and petrochemicals
4.	Oil Refining and related	Mining and quarrying	Mining and quarrying (incl. coal)
5.	High tech industries (professional and scientific equipment and TV electronics)		Machineries and manufactures (incl. food products and transport vehicles and equipment)
6.			Transport services including air transport

The analysis of energy-intensive industry sectors reviews available data, particularly energy balances, in order to identify those sectors with high energy-to-output ratios (with energy use per unit of economic output as our metric of energy intensity). Energy-intensity is used as a proxy for emissions-intensity, since this analysis does not consider changes in fuel mix. Applying this analysis to industry sectors shows a clear set of the 'top four' as shown in the table above.

The more energy-intensive sectors that stand out include basic metals (iron and steel as well as non-ferrous metals), non-metallic minerals, chemical and petrochemical products, and mining and quarrying. Together these comprise the 'top four' energy-intensive industrial sectors. This could be due to issues in the underlying data, or a real effect. A possible explanation could include a move to more tertiary sectors and a service economy. The other possibility would be that some energy efficiency measures are having an impact. Further analysis and longer, more consistent time-series would be needed to identify any such trend definitively. Combining the two underlying analyses, we identify as energy-intensive and trade-exposed (EITE) sectors as below.

Modelling the impacts of response measures for different scenarios

Having identified EITE sectors, we model the impact of response measures on South Africa under different scenarios. The scenarios considered include two reduction scenarios for Annex I – 25% (Scenario 1) and 40% (Scenario 2) below 1990 levels by 2020. Each of these two Annex I mitigation scenarios considers three different variants, distinguished by their assumptions about emissions trading (ET): (a) no emissions trading; (b) trade only among Annex I countries; and (c) access to carbon markets for NAI countries on a no-lose crediting basis. The 'No emissions trade' scenario is not considered likely, given existing and planned trading schemes, but provides a benchmark against which marginal abatement costs of other variants can be assessed. 'Annex I emissions trade' keeps the situation as with the Kyoto Protocol, with trading limited to developed countries but not extended to developing countries. The third variant considers a situation (as currently under negotiation for the period after 2012) in which NAI countries could trade on a 'no-lose crediting' basis.

The overall results of modelling the impacts of response measures suggest that, nationally, losses due to exports (coal and other) are offset by gains in exports of EITE sectors. However, this occurs only in a situation with emissions trading extended *beyond Annex I*, on the basis of no-lose crediting for NAI. In the case of the 'No ET' scenario and the 'Annex I ET' scenario, South Africa can expect real production losses, essentially because global competition for export of energy-intensive goods to Annex I countries intensifies on the back of falling fossil fuel prices (due to falling world demand) which may end up allowing some NAI regions such as China to gain from the competition, but resulting in losses for others such as South Africa. The overall losses, however, can be turned into potential gains if NAI regions are allowed to participate in a global ET scheme on a 'no-lose' basis.

In terms of potential gains from emissions crediting, South Africa might earn $285 billion in 2010 (for the 25% no-lose NAI mitigation scenario which rises to $470 million for the 40% scenario), $121 million in 2015 ($187m) and $64 million in 2020 ($68m). These potential earnings should be understood in the context of massive gains from emissions trade by Annex I countries: for example, the US would save $4288 million in 2020 in the 40% scenario.

A summary of the analysis can be described briefly in terms of winners and losers as follows:

Losers:

- 'Coal mining' irrespective of emissions trading regimes, due to reduced worldwide demand in all scenarios relative to Business as usual (BaU) (around -1.5 to -2% per annum in 'no ET' and 'Annex I ET' Scenarios and around -2.5 to -3% in 'Annex I ET with NAI no-lose crediting scenario). More specifically the figures above show (as well as those in Table 3.10 later) that across all three scenarios assessed (No ET, Annex I ET and Annex I ET and no-lose crediting) the coal sector stands to lose in terms of exports. In the last scenario, however, with no-lose crediting, the magnitude of this negative impact on the coal sector is significantly smaller, dropping from 5.4% in 'no ET' to 0.3% in 'no-lose crediting'.
- Other EITE sectors benefit from no-lose grading, but show some losses otherwise. These sectors are ferrous metals; agriculture, food and tobacco; chemical, rubber and plastic; motor vehicle and equipment; non-ferrous metals; other manufacture; international tourism. This is due to a combination of reduced demand (income effect) in Annex I countries and strong competition from other NAI countries in the supply of these goods to Annex I countries. 'Air transport' escapes from losses because of the benefit of reduced fuel costs due to reduced world demand for fuels (relative to BaU scenario). 'Iron and steel' and 'Other mining' avoid reduction due to 'leakage effects' to South Africa despite competition from other NAI countries.

Winners:

- 'Iron and steel', 'Other mining' and 'Air transport' in 'No ET' and 'Annex I ET' scenarios. The positive impact on 'Air transport' in South Africa is primarily due to reduced fuel costs due to reduced world demand for fuels (relative to BaU). The positive impacts on 'Iron and steel' and 'Other mining' in South Africa are partly due to potential 'leakage effects'.
- Most EITE sectors can turn losses into gains with 'No-lose trading' or even just 'Annex I trading' – except 'Coal mining', 'Iron and steel', and 'Other mining'. The potential losses outweighed by the positive income effect from improved efficiency in this ET regime, particularly if the sectors have access to the carbon markets directly.
- 'International tourism' – as with most sectors – shows positive impacts when there is 'Annex I ET with NAI no-lose crediting', but reports losses when there is no NAI no-lose crediting. This is (at least in part) due to the way this sector is created in this analysis.[1] Firstly, 'International tourism' shows negative impacts in 'No ET' and 'Annex I ET' scenarios because of the negative impacts on the 'Trade and other transport (except air transport)' and 'Other market services' sectors despite positive impacts on the air transport sector. Only in the 'Annex I with NAI no-lose crediting' scenario that this is turned around.

Robustness of the results and sensitivity analysis

Scenario 1 results show that there is an important shift in the pattern of economic activity and trade in the South African economy, and in particular on the EITE sectors, when the emissions trade arrangement is changed from 'No ET' or 'Annex I ET' to one with a 'no-lose credit' arrangement that allows NAI countries to earn credit for their efforts to reduce rather than to increase their own emissions in response to Annex I regions implementing climate policy measures. The reason is that the world as a whole can benefit from increased efficiency of climate policy and lower relative costs, and these benefits can flow on to all countries, including South Africa. Efficiency gains do not, however, address issues of equitable distribution of gains from trade across countries. The benefits of increased climate policy efficiency can be said to come from three sources:

[1] In this study we assume the expenditure level of 'International tourism' takes up a fixed proportion of the total expenditure level in sectors such as 'Other market services', 'Recreational and other services', 'Trade and transport' (see Table 3.2). This means when the total expenditure in these sectors changes (as a result of the climate response measures) we implicitly assume that the expenditure level by international tourists in these sectors also changes by the same proportion. This implies either that the expenditure level per tourist remains the same but the total number of tourists change or the number of tourists remains the same but the expenditure level per tourist has changed. Future studies may want to determine either or both of these two factors (in some exogenous simulations) to determine more accurately the changes in the proportion of international tourism expenditure level in these sectors over different periods rather than assuming them to remain unchanged, as is done in this study.

i) *Output or production expansion effect*, which sees the world economic output (and hence world demand for exports and imports) increased, even if the same climate policy target (for the world as a whole) is maintained.

ii) *Production efficiency effect*, which sees a switch from energy-inefficient (and emissions-inefficient) production activities to energy-efficient activities. This allows NAI countries to reduce their emissions (at least in relative terms), rather than increasing them, and this can bring benefits to both NAI regions and Annex I regions. Emissions can be reduced in the regions where it is most cost-effective to do so, meaning more mitigation takes place overall. Increased global mitigation has benefits for all countries in avoiding greater climate impacts, to which poor countries and communities are particularly vulnerable. This is the 'gains from (emission) trade' effect even if 'trade' here is still limited because it is confined only to a form of 'no-lose credit' given to NAI efforts at reducing emissions rather than by an explicit allocation of emissions permits.

iii) *Consumption efficiency effect*, which sees a switch of consumption activities from energy and emission intensive commodities/activities to less energy-intensive ones, even if the same level of welfare is maintained.

Depending on how these three effects interact, the impacts on South African energy-intensive and trade-exposed sectors will differ, as analysed under Scenario 1. Overall, the results of Scenario 2 help to reinforce the results of Scenario 1. They show that even with significant changes in the climate policy target (from 25% reduction to 40% reduction below 1990 emissions level for Annex I regions) the patterns of the impacts on South Africa do not change in any significant way, even though the magnitudes of the impacts will change (as expected). There is, however, a significant shift in the patterns of impacts when there is a change in emissions trading regime from 'Annex I ET' to 'Annex I ET *with* NAI no-lose crediting' remains with Scenario 2 as in Scenario 1.

Recommendations

The findings suggest that policy-makers might wish to consider the following:

- Negative impacts on the coal exports sector need to be considered for further studies.
- The mixed impacts on a range of sectors, including iron and steel, non-ferrous metals, chemicals, machinery and transport equipment, due to the differences inherent in different ET regimes, need to be considered for climate change considerations and negotiations, as well as for domestic industry policies. More specifically:
    - In terms of international climate policy negotiations. In particular, the potential gains (for South Africa as well as other developing countries) from an ET regime which allows for crediting for developing countries on a 'no-lose' basis. These potential gains are reflected in the results of this study and implies this is a promising policy approach. This approach can, therefore, be supported at the international negotiation level; but at the same time, further research needs to be conducted at the South African level to help identify more specifically the gains for South Africa and policies needed to facilitate these gains.
        - Research is needed to understand how this ET approach would work in practice in South Africa and to what extent it would help reinforce, or is in conflict with, domestic policies aimed at energy savings in South Africa, to move towards a low-carbon economy.
        - The impacts of industrial energy efficiency policies in South Africa and impacts of international ET regimes on South African sectors have domestic budgetary implications, such as profitability and employment, as well as environmental implications such as lower greenhouse gas emissions and future sustainable development of the country (Howells & Laitner, 2005). The key question is how to reconcile or combine these two consequences.
    - In terms of domestic climate policy on mitigation, the identified EITE sectors would either require a structured regulatory approach (e.g. benchmarks for emissions intensity in relation to their greater exposure), or incentives. Incentives could be domestically defined, e.g. through incentives to improve energy efficiency (and thus reduce intensity) or incentives in industrial policy for trade-exposed sectors.
- The impacts on agriculture and tourism deserve particular attention. Specific areas of focus for further work are suggested in section 5.

In general, previous studies have found the sectoral impacts of response measures to be negative. This report shows, however, that not all impacts will be negative, and in fact some sectors will experience a positive gain from the implementation of response measures to climate change by Annex I countries. South African policy-makers must thus be aware of not only the sectoral gains and losses but more importantly the magnitude of these losses, and the degree to which they can be balanced by gains. Ultimately, trade and climate policy-makers need to be prepared to deal with the energy-intensive and trade-exposed sectors identified in this report.

Contents

Acknowledgements

The Energy Research Centre (ERC) was commissioned by the Department of Environmental Affairs (DEA) to complete an assessment of the impact that response measures to climate change may have on South African trade. Harald Winkler and Meagan Jooste collaborated with Dirk van Seventer, independent research associate with Trade and Industrial Policy Strategies (TIPS), and Truong P Truong, Honorary Professor in Sustainable Transport Systems at the Institute of Transport and Logistics Studies, Faculty of Economics and Business, University of Sydney, Australia.

Dirk van Seventer took the lead in identifying the trade-exposed sectors of the South African economy (Section 2.1). The ERC identified the energy-intensive sectors of the economy (Section 2.2) and along with Dirk van Seventer highlighted the energy-intensive and trade-exposed sectors of the South African economy (Section 2.3). Truong P Truong took the lead in the modelling and writing of Section 3 where various climate change policy scenarios were assessed to determine the economy-wide implications of response measures to climate change, on the South African economy. The team as a whole commented on all sections and developed recommendations as input into Section 4. The ERC coordinated the overall compilation of the document.

The ERC would like to thank the DEA for making this research possible. We thank Solveig Crompton for her inputs and for coordinating comments on an earlier draft from a number of government departments and stakeholders. Any errors in this report remain as always the responsibility of the authors.

1. Response measures to climate change

1.1 Context

Article 4.8 of the United Nations Framework Convention on Climate Change (UNFCCC) provides that 'Parties shall give full consideration to … the impact of the implementation of response measures, especially on … (h) Countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products'. Article 2.3 of the Kyoto Protocol to the UNFCCC requires that developed country Parties (Annex I) 'shall strive to implement policies and measures…in such a way to minimize…effects on international trade' as well as minimizing the adverse effects on developing country Parties (Article 3.14). If Annex I Parties implement mitigation, they are assumed to buy less oil, coal or other fossil fuels. More recently, there has been debate whether a broader set of issues should be included here, for instance the issue of carbon footprint which implies products produced from developing countries and bought by developed countries, involve many intermediate production processes which may impact upon (as well as be impacted upon by) climate measures and therefore should be taken into account. Also, there is the issue of international tourism[2] which affects production and consumption activities of both developed and developing countries jointly.

1.2 Problem statement and relevance

In this context response measures are actions taken or initiated by developed countries (Annex 1) but with the impacts and ramifications flowing on to developing countries. The concern of developing countries therefore is in those impacts which to a greater or lesser extent depend on the degree of exposures of developing countries to trade (with or without the implementation of corresponding climate measures within the developing countries themselves). For example, South Africa or China may or may not want to impose a carbon tax or emissions reduction targets on their own industries, In such a situation, if Annex I countries decide to reduce their CO_2 emissions, some of the energy and emissions intensive activities in Annex I countries may be partially shifted to developing countries (due to a phenomenon known as 'leakage').[3] This phenomenon will work to the advantage of developing countries. However, a different phenomenon may also be adversely impacting developing countries. For example, South Africa exports coal to Annex I countries and therefore, due to climate response measures in Annex I countries, their demand for coal will be reduced. In this example, impacts on South Africa would be negative, unless this trade can be to a large extent be directed towards other non-Annex I countries. The analysis of the response measure impacts on South Africa must therefore distinguish between energy and emission-intensive industries (which can benefit if carbon constraints are imposed in Annex I countries), and the coal export sector which will be adversely affected. Also, some sectors such as agriculture, forestry and fishery, which may not be energy and emissions-intensive in its own production[4] but with a dependence on transport as a means to trade and transport is emission intensive sector, the sector can also be said to be impacted upon by climate response measures.

Negotiations are currently underway under the UNFCCC. There is thus a need to give effect to consolidated action to stem the tide of climate change, including as mandated by Ministers in the

---

2 One of the challenges faced when trying to model the impact of climate change responses specifically on tourism was the lack of model inputs. As a consequence, this is not dealt with at this stage.

3 The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report confirmed with 'high agreement and medium evidence that there may be effects from Annex I countries' action on the global economy and global emissions although the scale of carbon leakage remains uncertain' (IPCC 2007: 37). This phenomenon may to some extent be averted by other measures such as border tax adjustment (import tax or export subsidy based on differences in energy intensities between home and foreign countries and taking into account the presence or absence of carbon taxes). Also, in reality leakage may not be significant due to other constraints in developing countries such as production capacity, and product quality differentials etc.

4 Agriculture is not emissions intensive in terms of CO_2 emissions but can be if negative impacts on carbon sequestion due to land clearing is included and also Agriculture can be emissions intensive in terms of CH_4 and N_2O emissions (the latter due to the use of fertilizers). Agriculture, forestry and fishery therefore would be an important sector to consider (on its own right rather than as a sector relying on transport) if the issue of land use and emissions of CH_4 and N_2O are included.

Bali Action Plan and negotiations for further commitments for Annex I parties under the Kyoto Protocol. Addressing the risk of such adverse impacts for developing countries is an important factor in ensuring a successful outcome to the negotiations.

This project involves an economy-wide descriptive analysis and scenario modelling exercise to ascertain the possible effect of response measures to climate change on South African trade in the global arena. The focus of analyses is on identifying the energy-intensive and trade-exposed sectors of the South African economy, and determining how they would respond to the implementation of response measures.

1.3 Previous studies

One previous study has examined these issues. Overall, the Fund of Research into Industrial Development, Growth and Equity (FRIDGE) study found that the 'net effect of Policies And Measures (PAM's) are projected to have a marginally positive overall impact on the South African economy' (Consult 101, EC & IDC 2001). In other words, the impacts of response measures on South Africa are probably relatively small, and, if anything, marginally positive. Van Seventer *et al* (2001) similarly analyze the impact of implementing the Kyoto Protocol on the South African coal market and economy and find that, depending on the choice of climate change policy regime, South Africa can expect to experience negative or positive impacts on coal exports depending on the stringency of emission-reduction targets imposed on developed countries and South Africa respectively.

1.4 Purpose of this study

The South African economy derives much of its growth from production related to the energy-intensive sectors of its economy. As a non-Annex-I country, South Africa has no binding commitment to reduce its greenhouse gas (GHG) emissions by a quantifiable amount, but this may change in the future. The country's dependence on coal-intensive energy generation does make it a comparatively large producer of GHG emissions globally (Winkler & Zipplies, 2009a). In this report the scenarios to be examined are broader than those examined under the FRIDGE study as it will highlight the impacts which response measures have on sectors other than the manufacturing sector, including mining, agriculture and tourism. At the outset an overview of the current energy-intensive and trade-exposed sectors of the economy are identified in Section 2. This identification is then used to establish the impact of implementing response measures to climate change on South African trade. This is done through an economic simulation analysis in Section 3. Ultimately, the purpose of this analysis is to examine the impacts of climate change response measures on trade-offs that also involve South Africa's trade relations. In Section 5 this report provides recommendations that would offer information on response measures in the lead-up to the UNFCCC negotiations in Copenhagen, Denmark in December 2009. In the longer-term, the connections with trade and industrial policy need to be taken into account in developing national climate policy, as South Africa proceeds to define a sustainable development path that would make a transition to a low carbon economy and society.

2. Identifying the trade-exposed and energy-intensive sectors of the economy

2.1 Export and trade-intensive sectors of the economy

2.1.1 Introduction[5]

An important concern in the policy discussions around the impact of climate change on the South African economy is the degree to which response measures to climate change may impact on its trade with the rest of the world. The focus in this section is an analysis of the trade exposure of South African industry. For completeness, the impacts of such measures on imports are also assessed to understand the implications these have on overall trade of industries in South Africa.

A useful first step in a structured approach to energy intensive and trade exposed sectors under a carbon price may be to identify the industries concerned. This section identifies trade-intensive sectors, then energy-intensive ones separately, before combining the findings to identify EITE industries.

Before turning to the first analytical steps, some background of where South Africa comes from in this regard is briefly outlined. Minerals extractions and processing industries make a decisive contribution to South Africa's exports; historically, and at present, coal, gold and platinum comprise South Africa's top three exports by value; with iron ores and concentrates, these four categories comprised 32% of South Africa's exports in 2008 (DTI, 2005).

Not only are exports an important contributor to GDP in South Africa, the economy has become more open since the first democratic elections in 1994. An active policy of trade liberalisation resulted in a considerable reduction of the import tariffs during the 1990s. Competition from imports has seen many local producers struggle with employment losses often the consequence. But intermediate imports have become more affordable and final imports cheaper. Import competition has seen the general price level being reduced, while some argue that competitiveness has improved. However, there is no denying that exports increased considerably during the 1990s, whether this was associated with trade policy measures or with re-entering the global trade scene – or more likely due to a combination of the two. The net effect of trade liberalisation on employment has been debated intensely (for an overview see Edwards *et al*, 2009). In this section we consider industry level exports and more broadly, trade exposure as a way of describing the risk of negative impact on South Africa's trade position of responses to climate change, as developed countries undertake mitigation.

2.1.2 Macroeconomic context

By way of context we briefly sketch the macroeconomic picture of the last 10 years or so. Until a year ago, South Africa's economic growth had been well above its long-term average (of just over 3% since 1946), for almost 10 years. From a basis of low growth in the late 1990s to medium growth in the early years of the next decade, growth in real GDP (measured at basic prices in terms of annual percentage change) climbed to over 4% and remained there for the period June 2004 to June 2008. However, the global financial crisis has caused GDP growth to retreat to almost negative territory since March 2009, as can be seen in Figure 1 below. Here, it can also be seen that while growth in final consumption expenditure was elevated to very high levels of more than 6% over the same period; it started dropping off from the end of 2007, much earlier than GDP.

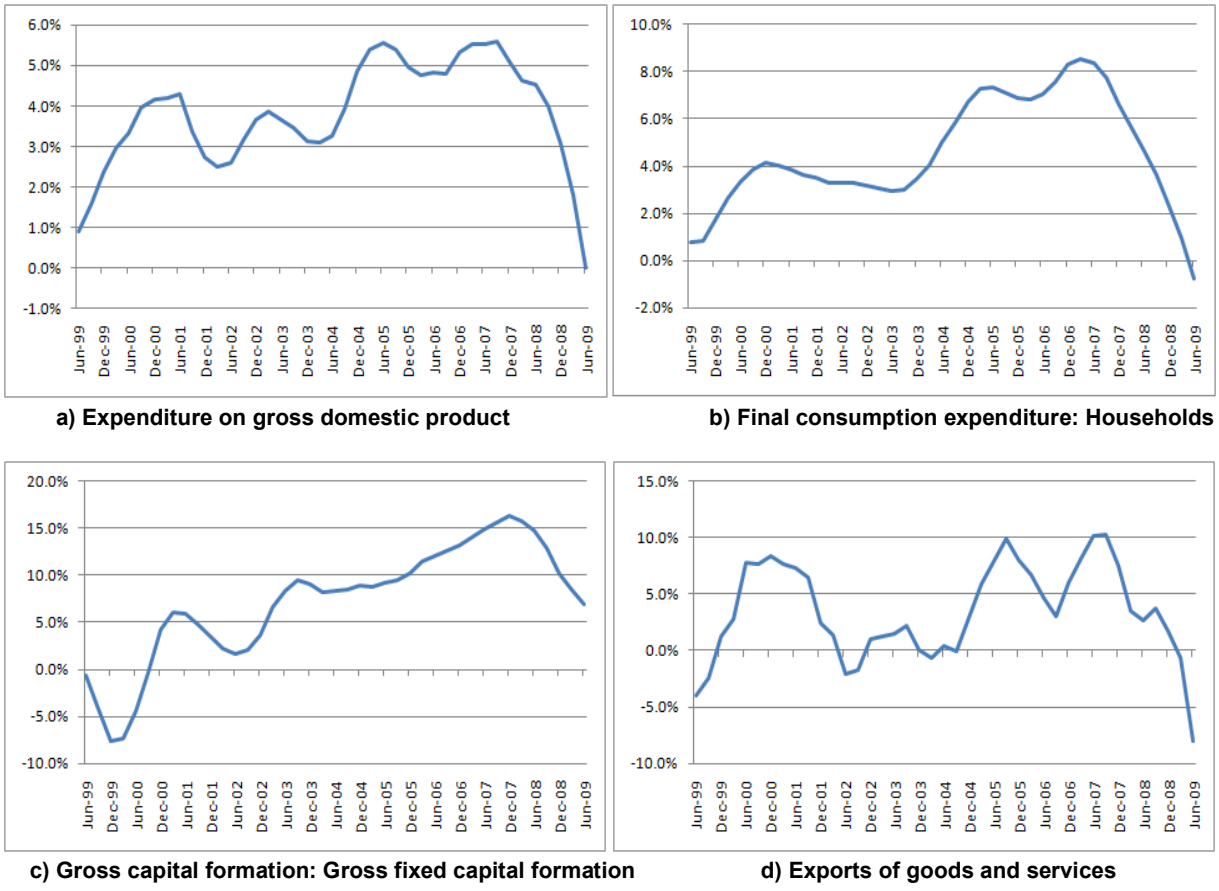
Relatively high GDP growth was maintained for longer, mainly due to growth in gross capital formation, associated with infrastructure spending. Export growth has been erratic over the last 10 years with some negative patches along the way. However, the recent decline is more marked, well below the period average, and coincides with the global financial crisis. These trends have brought about a marked shift in the contributions of main macroeconomic variables, as can be seen in Table 2.1. Final consumption has made way for investment (gross capital formation reflects investment), the latter rising from the 15% share that it had occupied for the previous two decades or so. Exports

[5] In this report the terms 'trade-intensive' and 'trade-exposed' are used interchangeably.

have maintained a share of just over 25% of GDP, slipping only slightly. With higher growth, imports tend to rise, as can be seen in the last column.

Table 2.1: Expenditure shares in GDP, constant 2000 prices
Source: South African Reserve Bank Quarterly Bulletin and own calculations

	Final consumption expenditure: households	*Final consumption expenditure: general government*	*Gross capital formation: gross fixed capital formation*	*Exports of goods and services*	*Imports of goods and services*
Ave last 4 quarters to Jun09	67.9%	19.6%	22.7%	26.3%	34.1%
Ave Sep04-Jun09 quarter	66.9%	19.2%	19.5%	26.5%	32.3%
Ave Sep99-Jun04 quarter	63.3%	18.5%	15.5%	27.0%	25.1%
Note: Row totals do not add to 100% since imports are reported here as a positive share while in the national accounts they would have to be subtracted from exports in order to arrive at net exports. Also, we have ignored inventory changes and residuals here.					



a) Expenditure on gross domestic product

b) Final consumption expenditure: Households

c) Gross capital formation: Gross fixed capital formation

d) Exports of goods and services

Note: *All figures reflect constant 2000 prices, annual percentage change*

Figure 2.1: Main macro economic variables, annual percentage change
Source: South African Reserve Bank Quarterly Bulletin (2009)

2.1.3 Trade-intensive commodities and industries

Although exports have maintained a fairly constant share of GDP over the last five years they may still differ widely across commodities and industries. With that in mind, we proceed by examining what the picture is at the commodity level followed by the industry level. We employ the United Nations Commodity Trade Statistics database (UNComtrade)[6] at the two digit level of commodity disaggregation (according to the Harmonised System or HS classification) as well as the Quantec Standardised Industry Database[7] which identifies 46 industries at varying levels of two to three digits South Africa Standardised Industry Classification (Statistics South Africa, 1993).

2.1.3.1 Commodities

With a global trade database such as UNComtrade we can examine South Africa's export performance in a global context. However, this can only be achieved with a classification that is common across countries. This forces us to examine commodities rather than industries (but we will return to them later). The next table shows the twenty-five (out of 100) most important two digit commodity clusters in South Africa's export basket over the last five years. They represent more than 90% of South Africa's total commodity exports.

Table 2.2: Merchandise trade for South Africa in global context
Source: UNComTrade global trade database (http://comtrade.un.org/)

	HS 2 Digit Code and Descriptor	1 Exports (R$'000) 2008	2 Ann Ave Growth 2004-08	3 Ave share 2004-08	4 Wrld Ann Ave Growth 2004-08	5 Wrld ave share 2004-08	6 Ave RCA 2004-08 Col3/ Col5	Comment
1	71: Pearls, precious stones, metals, coins, etc	104,085	17.0%	18.8%	18.2%	2.1%	8.8	Underperformer
2	72: Iron and steel	74,728	13.2%	12.0%	18.1%	3.0%	4.0	Underperformer
3	27: Mineral fuels, oils, distillation products, etc	58,927	17.9%	9.9%	18.4%	12.5%	0.8	Underperformer
4	87: Vehicles other than railway, tramway	60,925	18.6%	8.9%	8.0%	8.8%	1.0	Achiever in Adversity
5	84: Nuclear reactors, boilers, machinery, etc	52,411	21.4%	8.5%	10.9%	13.6%	0.6	Achiever in Adversity
6	26: Ores, slag and ash	59,976	46.0%	6.8%	27.8%	0.8%	8.8	Champion
7	76: Aluminium and articles thereof	18,153	11.6%	3.6%	14.9%	1.1%	3.2	Underperformer
8	08: Edible fruit, nuts, peel of citrus fruit, melons	13,104	8.0%	2.4%	6.7%	0.4%	5.4	Achiever in Adversity
9	85: Electrical, electronic equipment	12,945	14.7%	2.3%	8.6%	13.0%	0.2	Achiever in Adversity
10	28: Inorganic chemicals, precious metal compound, isotopes	14,765	13.9%	2.2%	16.5%	0.7%	3.1	Underperformer
11	29: Organic chemicals	10,467	14.3%	1.7%	7.5%	2.5%	0.7	Achiever in Adversity
12	73: Articles of iron or steel	10,811	19.1%	1.6%	18.8%	1.8%	0.9	Champion
13	22: Beverages, spirits and vinegar	8,611	8.2%	1.5%	11.4%	0.6%	2.5	Retreating from Declining Markets
14	39: Plastics and articles thereof	7,231	12.3%	1.1%	10.4%	3.2%	0.4	Achiever in Adversity
15	48: Paper & paperboard, articles of pulp, paper and board	6,194	13.5%	1.1%	6.2%	1.3%	0.9	Achiever in Adversity
16	94: Furniture, lighting, signs, prefabricated buildings	4,860	-2.6%	1.1%	9.7%	1.2%	0.9	Retreating from Declining Markets
17	38: Miscellaneous chemical products	5,261	12.6%	1.0%	15.0%	1.0%	1.1	Underperformer
18	74: Copper and articles thereof	5,869	46.2%	1.0%	20.2%	0.9%	1.1	Champion
19	88: Aircraft, spacecraft, and parts thereof	4,454	17.8%	0.9%	10.5%	1.4%	0.6	Achiever in Adversity
20	44: Wood and articles of wood, wood charcoal	3,622	-4.6%	0.8%	4.1%	0.9%	0.9	Retreating from Declining Markets
21	47: Pulp of wood, fibrous cellulosic material, waste etc	4,685	10.4%	0.8%	11.9%	0.3%	3.0	Retreating from Declining Markets
22	03: Fish, crustaceans, molluscs, aquatic invertebrates nes	4,022	5.7%	0.8%	3.3%	0.5%	1.5	Achiever in Adversity
23	75: Nickel and articles thereof	2,541	-10.3%	0.7%	19.0%	0.2%	3.1	Underperformer
24	40: Rubber and articles thereof	3,346	5.2%	0.6%	12.6%	1.0%	0.6	Underperformer
25	20: Vegetable, fruit, nut, etc food preparations	3,081	4.0%	0.6%	12.1%	0.3%	1.9	Retreating from Declining Markets
26	90: Optical, photo, technical, medical, etc apparatus	3,615	17.4%	0.6%	8.5%	3.0%	0.2	Achiever in Adversity
27	17: Sugars and sugar confectionery	2,059	0.2%	0.5%	9.2%	0.2%	2.4	Retreating from Declining Markets
	Total	**610,341**	**16.5%**		**12.1%**			

Note: since the data is reported in US$ and subsequently converted back to local currency with the average exchange rate for the year 2008, total commodity exports does not match official national accounts data as it excludes services trade.

6 See the website at http://comtrade.un.org/.
7 See the website at http://www.quantec.co.za/data/easydata-rsa-standardised-industry.

Heading the list in terms of share in South Africa's export basket is the export of gold and diamonds (HS71), followed by iron and steel (HS72), coal (HS27), motor vehicles (HS87) and machinery (HS84), iron ores, aluminium, fruits, electrical equipment and inorganic chemicals make up the rest of the top ten. Although measured in nominal terms, average annual growth over the last five years has been higher than 10% for all but one of these clusters, namely HS08 edible fruits, nuts, peel of citrus fruit and melons. This may seem high, but in the case of the top three clusters, global trade has actually increased at an even faster rate (in the range of 18%) and at a rate that is faster than merchandise trade's global average of 12.1%. This means that South Africa is losing share in markets that are growing in importance, hence the 'Underperformer' comment in the last column. In the case of the first two clusters [Gold and diamonds (HS71), followed by Iron and steel (HS72)] their share in South Africa's export basket (18.8% and 12% respectively) is much higher than the share of these clusters in global trade (2.1% and 3% respectively, see column 5). Thus, South Africa appears to have a revealed comparative advantage (RCA>1, see column 6)[8] in two 'underperforming' clusters. Overall, this means that while these commodities clusters are a key to South Africa, in the global context, the country's share in these vital global markets is declining.

In the case of HS87 Motor vehicles and HS84 Machinery, the picture is different, in that South Africa is outperforming the rest of the world in clusters that seem to have been declining in importance (in that their global growth has been lower than average). The star performer in South Africa's export basket is HS26 Ores where global trade has increased more than average and South African producers have managed to grow even faster. Hence, their share in this expanding global market has increased. Similarly, other 'champions' are articles of HS73 Iron & steel products and HS74 Copper and articles thereof.

Interestingly, agriculture and related clusters do not feature much in this line-up. Although HS08 Fruits are located in the top ten, HS22 Beverages and HS20 Vegetables are not only much lower down the share ranking in row 13 and 25, their exports over the last five years have been characterised by 'retreating from declining markets' in that these two clusters lost share in a global market that increased by less than average. This is in and of itself, is not a bad strategy. Global decline can also be noted for the HS08 Fruits cluster (row 8), but here South African exporters fare better, perhaps not a good strategy unless one is focusing on specific niche markets with growth potential.

Chemicals and related clusters (rows 11, 14, 17 and 24) on the whole have performed with mixed results over the past five years with the common thread that none of them are star performers with hardly a noteworthy RCA. On the other hand, while paper products are performing relatively well, the global market is not. Similarly, the global markets for wood and wood pulp products are underperforming but at least South African exporters are not expanding here, although there appears to be a comparative advantage in wood pulp.

To summarize this overview of South Africa's merchandise export trends, it would appear that there is some limited evidence of moving away from traditional export clusters in the resources towards higher-added-value clusters such as machinery, transport and other equipment. Growth in exports of these higher value clusters has increased at a higher rate than at the global level and market shares have increased. However, at a global level these clusters have grown at lower than global average rates. Global merchandise growth seems to have tilted in recent times somewhat back in the direction of trade in the more traditional resources and it would appear that South Africa has not benefitted as much as other countries, such as perhaps Australia.

2.1.3.2 Industries

Since the focus of this report is on how industries would react to the implementation of climate change response measures, we now consider exports at the industry level. The aim is to examine whether exports have become more or less important in terms of the industry's overall production.

---

[8] RCA of a commodity or cluster of commodities is the ratio of the share of these commodities in South Africa's export basket and the share of these commodities in world trade (excluding South Africa's trade, although that wouldn't make much difference. For example, if the share of cluster 71 (essentially gold and diamonds) in South Africa's trade is 17% and 2.2% in world trade respectively, the RCA is 17%/2.2% =8.8. Thus, cluster 71 is 8.8 times more important to South Africa's exports than to the rest of the world and it can therefore be said that South Africa has a RCA in this cluster. This RCA can be the result of natural endowments or policy intervention (motor vehicles), the method, at least in this simple form, cannot make the distinction.

We employ South African-based industry level export data from the Quantec Standardised Industry Database (SASID) in order to examine export intensive industries. Results are shown in Table 3. We calculate averages for four five-year periods in order to examine broad structural changes over the last twenty years.

It can be seen that the general story of Table 2.2 is mirrored and extended when we express exports as a proportion of total output (all measured in constant 2000 prices) of the identified industries. We also add the long-term annual average growth rate (calculated as an ordinary least squares time trend) for the full period 1989-2008. As before, we find resource-based industries at the top of the rankings, as most of their output is exported. Apart from gold mining, which has experienced negative export growth; this is the case for coal, other mining, metals, machinery and basic chemicals. Motor vehicles and related has experienced a spectacular increase in the export intensity as well as TV and related communications equipment and agriculture. The share of output of the latter that is exported rose from an average of only 6% in the early part of the 1990s to almost 18% in the last five years. A similar increase was recorded for catering and accommodation services, which constitutes the bulk of the tourism sector. On the other hand significant declines in export intensity have been recorded for textiles and clothing, wood products, paper and related products as well as food and beverage producers.

Thus, while there is some cursory evidence that exports have moved into non-traditional value adding activities such as machinery, transport equipment and electronics, there has been a move out of others such as textiles, clothing and food. However, the bias in export-intensive industries remains towards resource based activities in mining and related activities while agriculture has also joined these ranks. Services related to tourism, such as in the catering and accommodation sectors, have become more export intensive as well.

Table 2.3: Export Intensities ranked according to 2008 ratio of exports to gross output (2000 constant prices)

Source: Quantec Standardised Industry Database and own calculation

	Industry	Ave 89-93	Ave 94-98	Ave 99-03	Ave 04-08	Change 89-08
1	Gold & uranium ore mining	98.0%	96.3%	95.4%	94.2%	-4.9%
2	Other mining	56.6%	53.6%	61.9%	77.1%	5.3%
3	Coal mining	34.4%	36.4%	48.2%	56.7%	5.1%
4	Machinery & equipment	14.6%	34.1%	34.3%	48.7%	9.8%
5	Basic non-ferrous metals	66.5%	61.5%	39.1%	45.1%	1.9%
6	Basic iron & steel	53.1%	58.9%	43.0%	44.8%	3.6%
7	Leather & leather products	30.8%	54.6%	35.0%	28.1%	4.2%
8	Basic chemicals	31.0%	46.2%	29.2%	27.6%	4.5%
9	Motor vehicles, parts & accessories	7.6%	12.8%	24.6%	27.2%	19.6%
10	Television, radio & communication equipme	9.5%	27.3%	26.8%	25.3%	8.8%
11	Other industries	36.5%	27.0%	27.7%	23.8%	0.3%
12	Furniture	11.3%	41.1%	35.3%	22.9%	8.6%
13	Professional & scientific equipment	29.8%	54.8%	31.9%	21.1%	1.2%
14	Agriculture, forestry & fishing	6.3%	9.3%	12.8%	17.7%	9.8%
15	Catering & accommodation services	9.0%	14.4%	15.4%	17.5%	8.0%
16	Other transport equipment	20.2%	38.5%	26.5%	16.2%	4.2%
17	Rubber products	6.2%	15.4%	15.4%	11.8%	7.3%
18	Paper & paper products	19.2%	27.9%	18.8%	11.8%	0.1%
19	Transport & storage	9.2%	11.8%	10.9%	10.4%	6.1%
20	Coke & refined petroleum products	3.9%	23.3%	18.3%	9.5%	13.3%
21	Beverages	4.4%	9.8%	10.8%	9.3%	7.1%
22	Wood & wood products	9.6%	18.3%	16.4%	9.1%	3.5%
23	Electrical machinery	8.4%	13.3%	9.3%	8.5%	4.6%
24	Metal products excluding machinery	7.9%	10.9%	9.0%	8.1%	1.7%
25	Glass & glass products	12.1%	12.9%	12.1%	7.1%	0.3%
26	Plastic products	3.8%	7.7%	6.6%	6.9%	8.5%
27	Non-metallic minerals	5.7%	11.0%	9.1%	6.3%	2.9%
28	Other chemicals & man-made fibres	5.8%	9.2%	7.1%	6.3%	6.1%
29	Communication	3.8%	3.5%	4.2%	5.8%	16.4%
30	Textiles	18.8%	18.5%	10.8%	5.7%	-6.6%
31	Wholesale & retail trade	3.0%	4.9%	5.3%	4.8%	8.0%
32	Food	8.9%	10.9%	8.3%	4.8%	-1.0%
33	Tobacco	2.5%	5.2%	5.3%	4.6%	7.0%
34	Finance & insurance	4.5%	5.1%	4.4%	3.9%	6.4%
35	Wearing apparel	13.6%	14.4%	12.7%	3.4%	-8.2%
36	Business services	1.2%	1.7%	2.2%	2.9%	12.7%
37	Printing, publishing & recorded media	0.7%	2.9%	2.2%	2.4%	8.7%
38	Medical, dental & other health & veterinary	1.2%	1.1%	1.4%	1.9%	11.1%
39	Other producers	0.4%	0.6%	0.8%	1.5%	10.6%
40	Other community, social & personal service	1.3%	1.4%	1.2%	1.2%	7.2%
41	Footwear	4.2%	7.0%	2.5%	0.7%	-12.4%
42	Electricity, gas & steam	0.8%	1.0%	0.8%	0.6%	1.2%
43	Civil engineering & other construction	0.2%	0.3%	0.2%	0.1%	-1.7%
44	Water supply	0.0%	0.0%	0.0%	0.0%	0.0%
45	Government	0.0%	0.0%	0.0%	0.0%	0.0%
46	Building construction	0.0%	0.0%	0.0%	0.0%	0.0%

We can also express the industries' exports as a share of total exports (of all industries). In that way we get a feel for which the most important industry contributors to South Africa's exports are. In a sense, it will be a repeat of column 3 of Table 2.2 but now expressed in terms of total exports (of goods and services) as opposed to merchandise exports as is the case in that table. The results are shown in Table 2.4.

Table 2.4: Export shares ranked according to the last period 2008 (2000 constant prices)
Source: Quantec Standardised Industry Database and own calculations

	Industry	Ave 89-93	Ave 94-98	Ave 99-03	Ave 04-08	Change 89-08
1	Other mining	18.4%	16.3%	16.9%	21.5%	5.3%
2	Motor vehicles, parts & accessories	1.7%	2.8%	8.1%	10.4%	19.6%
3	Basic iron & steel	9.1%	8.4%	7.8%	8.4%	3.6%
4	Gold & uranium ore mining	23.1%	14.9%	10.0%	5.5%	-4.9%
5	Transport & storage	3.9%	4.4%	4.9%	5.0%	6.1%
6	Machinery & equipment	2.1%	4.0%	3.9%	4.8%	9.8%
7	Coal mining	4.3%	3.9%	4.6%	4.7%	5.1%
8	Wholesale & retail trade	2.6%	3.7%	4.4%	4.3%	8.0%
9	Basic chemicals	3.9%	5.0%	4.4%	4.2%	4.5%
10	Agriculture, forestry & fishing	1.7%	2.2%	3.0%	3.9%	9.8%
11	Basic non-ferrous metals	3.9%	4.3%	3.1%	2.9%	1.9%
12	Other industries	5.2%	3.0%	3.1%	2.7%	0.3%
13	Finance & insurance	1.8%	2.0%	2.1%	2.4%	6.4%
14	Business services	0.7%	0.9%	1.5%	2.2%	12.7%
15	Communication	0.4%	0.5%	1.2%	2.1%	16.4%
16	Coke & refined petroleum products	0.5%	3.0%	3.5%	1.7%	13.3%
17	Catering & accommodation services	0.9%	1.1%	1.3%	1.6%	8.0%
18	Food	3.4%	3.5%	2.5%	1.5%	-1.0%
19	Paper & paper products	2.4%	2.9%	2.2%	1.3%	0.1%
20	Other chemicals & man-made fibres	0.9%	1.4%	1.4%	1.1%	6.1%
21	Metal products excluding machinery	1.3%	1.4%	1.2%	0.9%	1.7%
22	Beverages	0.6%	0.9%	0.9%	0.8%	7.1%
23	Furniture	0.4%	1.2%	1.2%	0.8%	8.6%
24	Electrical machinery	0.6%	0.9%	0.7%	0.6%	4.6%
25	Other transport equipment	0.7%	0.7%	0.6%	0.5%	4.2%
26	Television, radio & communication equ	0.3%	0.6%	0.5%	0.5%	8.8%
27	Wood & wood products	0.5%	0.8%	0.8%	0.5%	3.5%
28	Plastic products	0.2%	0.4%	0.4%	0.4%	8.5%
29	Medical, dental & other health & veter	0.2%	0.1%	0.2%	0.4%	11.1%
30	Non-metallic minerals	0.4%	0.6%	0.4%	0.4%	2.9%
31	Leather & leather products	0.3%	0.5%	0.4%	0.3%	4.2%
32	Rubber products	0.2%	0.4%	0.4%	0.3%	7.3%
33	Professional & scientific equipment	0.4%	0.5%	0.3%	0.3%	1.2%
34	Textiles	1.2%	1.0%	0.6%	0.2%	-6.6%
35	Other producers	0.1%	0.1%	0.1%	0.2%	10.6%
36	Wearing apparel	1.0%	0.8%	0.6%	0.1%	-8.2%
37	Other community, social & personal se	0.1%	0.1%	0.1%	0.1%	7.2%
38	Tobacco	0.1%	0.2%	0.2%	0.1%	7.0%
39	Printing, publishing & recorded media	0.1%	0.2%	0.1%	0.1%	8.7%
40	Glass & glass products	0.2%	0.2%	0.1%	0.1%	0.3%
41	Electricity, gas & steam	0.1%	0.1%	0.1%	0.1%	1.2%
42	Civil engineering & other construction	0.0%	0.0%	0.0%	0.0%	-1.7%
43	Footwear	0.1%	0.1%	0.0%	0.0%	-12.4%
44	Water supply	0.0%	0.0%	0.0%	0.0%	0.0%
45	Government	0.0%	0.0%	0.0%	0.0%	0.0%
46	Building construction	0.0%	0.0%	0.0%	0.0%	0.0%
	Total	100.0%	100.0%	100.0%	100.0%	4.4%

Other mining, including platinum and iron and other ores, is in this line-up the most important industry in terms of share in total exports. The share has increased somewhat over the full period, but the highest increase in share of exports is reserved for the motor vehicle industry, from only 3% in the mid 1990s to more than 10% in the last five-year period. On the other hand, gold and related mining has declined in a dramatic way over the full period, from 23% in the early 1990s to just over 5% in the last five years. Basic metals (hereafter referring to iron and steel and non-ferrous metals) have managed to maintain their combined share at around 12% and the same applies to coal mining, which managed to maintain a share of just under 5% which makes coal exports one of the top 10 exporting industries in this line-up of 46. Agriculture has also managed to improve its share in South Africa's export basket from less than 2% in the early 1990s to double that over the most recent five-year period. However, the share of food production in the basket has been halved from more than 3% to 1.5%. Remarkable is the high importance of transport and storage and trade. Note also how the share of catering and accommodation increases from less than 1% to 1.5%.

On the other hand textiles and clothing have seen their share in South Africa's export basket being reduced over the last 20 years, combined from 2.2% to less than half a percent. Basic chemicals are an important contributor to the export basket as well, with a share of about 4%, which has come down somewhat from the 5% that was recorded in the mid 1990s. Some other relatively big movers in terms of the share of the relevant industry's production, such as leather, electronic equipment and accommodation (see Table 4) actually turn out to be small players in the greater scheme contribution to the total export basket.

However, the overriding observation remains that resources and related activities like basic metals and basic chemicals are the key driver of South African exports with some diversification elsewhere into added value activities such as machinery and transport equipment. Although there are signs of further diversification they are limited to industries with very low shares including catering and accommodation. Agriculture is an exception in that its share is now up to 4% of South Africa's export basket, but this has been offset to some degree by a decline in the exports of food products. This is an interesting trend in that it suggests a reversing of the beneficiation process that may to some degree be taking place in the minerals resources complex.

2.1.3.3 Trade is exports plus imports

Trade involves exports as well as imports and an often used measure of exposure to trade is the ratio of the sum of exports and imports to what is produced locally. Imports could also refer to intermediate imports by those industries, i.e., imports of production inputs. Here, the focus is more on the degree to which an industry relies on imported (or traded) inputs.

Trade intensive industries have been defined as those in which exports and imports combined are more than 40% of their domestic output (Wainwright, 2002: 2). Other references use 60% as the threshold. We keep an open mind and present results for 46 industries over the last two decades in four five-year periods as shown in Table 2.5. It can be seen that the industries that are most trade intensive are not only mining and heavy industries, but include also TV, radio and communications equipment producers. As expected, services industries feature low, while light manufacturing industries such as food, beverages, textiles, clothing (referring hereafter to 'wearing apparel'), paper, machinery and electrical machinery as well as plastic products and agriculture can be seen to be exposed to trade for less than 30% of their domestic production.

As before, we examine change in trade exposure over the twenty year period by estimating log linear time trends by means of simple ordinary least squares (OLS) regression analyses. The results are shown in the last column of Table 5. Most industries have seen an increase in their exposure to trade. In particular, other and coal mining, machinery, electronics and motor vehicles as well as agriculture have seen large increases. Notable exceptions are basic metals and basic chemicals as well as textiles and paper. However, the basic metals and chemicals remain industries with very high trade exposure in spite of a decline.

Table 2.5: Trade Intensities based on exports and direct intermediate imports (2000 constant prices)

Source: Quantec Standardised Industry Database and own calculations

Industry	Ave 89-93	Ave 94-98	Ave 99-03	Ave 04-08	Change 89-08
1 Gold & uranium ore mining	103.2%	104.5%	102.7%	102.6%	0.0%
2 Other mining	64.6%	63.2%	69.0%	85.1%	1.8%
3 Machinery & equipment	29.0%	55.2%	51.2%	69.6%	5.4%
4 Basic iron & steel	73.9%	83.0%	63.2%	68.7%	-0.9%
5 Basic non-ferrous metals	87.5%	84.1%	56.5%	66.1%	-2.4%
6 Coal mining	43.4%	47.7%	56.4%	66.0%	2.9%
7 Television, radio & communication equipme	29.7%	59.6%	57.1%	60.8%	4.6%
8 Motor vehicles, parts & accessories	20.2%	31.0%	43.6%	52.7%	6.8%
9 Basic chemicals	54.8%	73.0%	49.1%	51.3%	-1.1%
10 Other transport equipment	32.4%	57.2%	54.3%	50.3%	3.6%
11 Other industries	52.5%	44.6%	43.7%	44.6%	-1.0%
12 Coke & refined petroleum products	32.0%	54.1%	46.1%	42.0%	1.3%
13 Leather & leather products	40.6%	69.5%	45.6%	39.5%	-0.9%
14 Professional & scientific equipment	44.1%	71.7%	45.2%	36.8%	-1.4%
15 Furniture	20.4%	53.1%	43.6%	31.7%	2.2%
16 Non-metallic minerals	22.6%	31.3%	26.3%	28.4%	1.1%
17 Agriculture, forestry & fishing	12.2%	19.2%	21.0%	27.9%	5.0%
18 Rubber products	19.4%	31.7%	27.3%	25.5%	1.5%
19 Electrical machinery	21.2%	29.8%	21.7%	23.8%	0.1%
20 Paper & paper products	28.7%	40.9%	28.3%	22.0%	-2.3%
21 Other chemicals & man-made fibres	19.9%	27.5%	20.6%	21.8%	0.1%
22 Glass & glass products	26.2%	29.4%	24.9%	21.5%	-1.4%
23 Catering & accommodation services	12.0%	18.0%	18.4%	21.0%	3.5%
24 Textiles	31.4%	34.9%	23.2%	20.1%	-3.3%
25 Transport & storage	13.4%	17.8%	18.3%	19.5%	2.4%
26 Plastic products	15.4%	22.6%	17.5%	19.5%	1.2%
27 Metal products excluding machinery	18.3%	24.4%	17.6%	18.6%	-0.6%
28 Footwear	14.6%	27.1%	17.5%	17.9%	0.8%
29 Wood & wood products	15.8%	26.5%	23.0%	16.9%	0.0%
30 Communication	7.9%	12.8%	13.0%	16.0%	4.5%
31 Beverages	9.6%	16.6%	15.7%	15.0%	2.9%
32 Wearing apparel	25.5%	28.2%	22.8%	14.4%	-3.4%
33 Food	15.2%	18.8%	14.1%	12.0%	-1.7%
34 Printing, publishing & recorded media	7.6%	13.0%	9.8%	11.8%	2.2%
35 Tobacco	7.8%	12.6%	10.0%	10.2%	1.7%
36 Civil engineering & other construction	11.1%	13.4%	8.9%	10.1%	-1.3%
37 Other community, social & personal service	7.7%	11.1%	9.3%	9.8%	1.2%
38 Medical, dental & other health & veterinary	8.8%	9.4%	7.8%	9.4%	0.1%
39 Building construction	7.9%	9.7%	6.6%	7.7%	-1.0%
40 Wholesale & retail trade	5.7%	8.3%	7.8%	7.3%	1.5%
41 Business services	4.4%	5.1%	5.5%	6.8%	2.7%
42 Water supply	4.5%	4.3%	3.9%	5.7%	1.2%
43 Government	3.0%	3.0%	3.2%	5.0%	3.5%
44 Electricity, gas & steam	2.5%	3.1%	3.6%	4.9%	4.2%
45 Finance & insurance	5.7%	7.1%	5.7%	4.9%	-1.3%
46 Other producers	2.6%	3.6%	3.6%	4.6%	3.5%

2.1.3.4 Industry level trade exposure: direct and indirect import measure

The analysis including imports so far is based on direct intermediate imports by the relevant industries. It may also be interesting to examine what the value of intermediate imports is that is embodied directly and indirectly in the final demand for goods and services of each of the industries. Given the production structure of the South African economy as captured by an input-output table, it is then possible to determine the value of direct and indirect intermediate imports that are required to satisfy the actually observed final demand for goods and services of an industry.[9] In this way it may

[9] Thus, the given value of total intermediate imports as calculated in Table 2.5, could be redistributed across industries according to the intermediate import to output ratios and the Leontief Inverse (their product being the intermediate import multipliers) and the associated Final demand of these industries. Leontief Inverse Matrices are derived from Industry by Industry Input-Output tables (in constant 2000 prices) that form the basis for the Quantec Industry Data Series. While Input-Output tables are not available for every single year, they have been interpolated based on national accounts data, industry value added data, industry trade and industry reduction data amongst

be possible that direct and indirect intermediate imports are for some industries lower than their direct intermediate imports. This is likely because intermediate imports of some industries are used towards the final demand of other industries. Ultimately this, it may be argued, should be attributed to these other industries' 'trade exposure' and not to those to which it had initially been credited to. In a sense, we are interested here in the vertical integration of production and how intermediate imports are used downstream. The trade exposure based on exports and direct and indirect intermediate imports are shown for the same industries in Table 2.6.

It can be seen that most industries with high direct trade intensities (see Table 2.5 above) also record high total (i.e. direct and indirect) trade intensities. The reason is that the export component of the industry trade intensity measure is as intense as before and very much so in case of the resources-related industries. There are, however, a couple of notable changes in the rankings over the last 5 year period of observation. Basic metals and basic chemicals are more trade-intensive when indirect intermediates are taken into account, as well as leather, furniture and specialised equipment. The latter three are, however relatively small industries. Textiles, clothing, footwear, as well as paper and related products are more trade-intensive, but coal and other mining, machinery and TV, radio and communications equipment are considerably less trade-intensive industries, as are, most importantly, the motor vehicle and related industries.

The main message from the indirect intermediate imports calculations shown in Table 2.6 is that important industries such as coal mining as well as motor vehicles' trade intensity is now lower than the threshold of 40% while machinery and equipment producers have become more trade intensive.

Rankings based on direct or total (i.e. direct and indirect) trade intensities still report the usual suspects as the industries that are exposed to trade more than average. They include mining, basic metals, machinery, chemicals, oil refining and related, as well as more high tech industries such as professional and scientific equipment and TV and electronics. Tertiary industries are less exposed even when taken indirect intermediate imports into account.

Note that the exposure to trade based on the indirect import measure is less volatile than when imports are measured directly. None of the rates of change in this trade exposure measure are larger than 10%. Interestingly, some of the signs in the rate of change have reversed. For example, basic metals and basic chemicals see their exposure increase somewhat, while they reported significant declines when the measure was just based on direct imports only. This means that these industries have, through their backward linkages, become more exposed to trade, in particular through their imports. The opposite is, to some degree, the case for machinery and electronics equipment as well as paper.

others that are available at an annual basis. No data was available for 2008 and the 2007 Leontief Inverse was used instead.

Table 2.6: Trade Intensities based on exports and direct & indirect intermediate imports (2000 constant prices)

Source: Quantec Standardised Industry Database and own calculations

Industry	Ave 89-93	Ave 94-98	Ave 99-03	Ave 04-08	Change 89-08
1 Gold & uranium ore mining	106.7%	107.0%	107.7%	108.7%	0.1%
2 Basic non-ferrous metals	85.8%	80.0%	78.5%	80.2%	-3.2%
3 Basic iron & steel	68.8%	71.4%	74.4%	77.3%	-1.4%
4 Leather & leather products	40.6%	48.8%	55.1%	63.0%	-0.6%
5 Other mining	64.7%	63.9%	62.8%	62.4%	2.2%
6 Basic chemicals	43.1%	47.2%	54.4%	60.6%	-1.6%
7 Professional & scientific equipment	39.8%	43.5%	47.7%	55.7%	-0.8%
8 Furniture	25.0%	30.8%	40.4%	48.7%	2.3%
9 Other industries	51.0%	48.6%	47.4%	45.1%	-0.7%
10 Machinery & equipment	26.9%	29.5%	35.9%	42.8%	6.5%
11 Coal mining	40.8%	38.9%	38.3%	39.8%	3.4%
12 Coke & refined petroleum products	18.3%	25.0%	31.7%	39.0%	1.3%
13 Television, radio & communication equipme	26.4%	28.6%	32.2%	38.3%	4.6%
14 Other transport equipment	28.9%	31.8%	30.9%	35.2%	1.5%
15 Wearing apparel	27.7%	30.8%	33.1%	34.4%	-0.7%
16 Paper & paper products	23.7%	25.8%	30.8%	33.1%	-3.3%
17 Motor vehicles, parts & accessories	24.1%	26.2%	28.6%	30.6%	5.5%
18 Footwear	19.3%	22.7%	25.8%	29.4%	2.0%
19 Textiles	26.6%	27.2%	28.2%	29.1%	-3.1%
20 Electrical machinery	18.2%	20.0%	22.4%	24.9%	0.8%
21 Food	20.4%	21.6%	23.2%	24.7%	0.0%
22 Rubber products	14.2%	15.9%	18.8%	21.6%	3.2%
23 Beverages	14.4%	16.4%	18.4%	20.3%	2.9%
24 Tobacco	13.9%	15.8%	18.0%	20.0%	2.6%
25 Catering & accommodation services	15.8%	16.6%	17.9%	19.4%	3.1%
26 Wood & wood products	11.6%	14.5%	17.0%	18.7%	-0.6%
27 Other chemicals & man-made fibres	15.0%	15.8%	17.0%	18.6%	0.3%
28 Glass & glass products	16.9%	16.9%	16.7%	17.2%	-3.3%
29 Metal products excluding machinery	14.5%	14.8%	15.6%	16.7%	0.3%
30 Civil engineering & other construction	16.5%	16.1%	15.7%	16.0%	-0.7%
31 Transport & storage	13.4%	14.0%	14.9%	15.8%	1.7%
32 Building construction	12.1%	12.1%	12.9%	13.6%	-0.7%
33 Non-metallic minerals	8.5%	10.1%	12.0%	13.5%	0.5%
34 Agriculture, forestry & fishing	10.4%	11.1%	12.1%	13.2%	5.4%
35 Other community, social & personal service	10.1%	10.7%	11.4%	12.2%	2.0%
36 Medical, dental & other health & veterinary	10.9%	11.1%	11.5%	11.9%	0.7%
37 Plastic products	8.6%	9.0%	9.9%	10.7%	0.1%
38 Wholesale & retail trade	6.6%	7.0%	7.6%	8.3%	2.1%
39 Communication	6.0%	6.7%	7.3%	7.9%	4.0%
40 Finance & insurance	5.5%	5.6%	5.9%	6.2%	-0.9%
41 Printing, publishing & recorded media	3.8%	4.3%	4.7%	6.2%	3.6%
42 Government	4.9%	5.0%	5.0%	5.0%	4.5%
43 Business services	4.5%	4.6%	4.6%	4.9%	2.3%
44 Other producers	3.0%	3.0%	3.2%	3.5%	3.9%
45 Electricity, gas & steam	2.9%	3.0%	3.2%	3.4%	2.9%
46 Water supply	2.0%	1.9%	1.9%	1.9%	4.4%

2.1.4 Summary

Although exports have maintained a fairly constant share of GDP over the last five years, they may still differ widely across commodities and industries. With that in mind, we examined what the export picture is at the commodity level as well as the industry level. At the commodity level we showed that there is some limited evidence that South Africa's merchandise export trends are moving away from traditional export clusters in the resources towards higher added value clusters such as machinery, transport and other equipment. Growth in exports of these higher value clusters has increased at a higher rate than at the global level and market shares have increased. However, at a global level these clusters have grown at lower than global average rates. Ironically, global merchandise growth seems to have tilted in recent times somewhat back in the direction of trade in

the more traditional commodities and it would appear that South Africa has not benefited as much as other countries such as perhaps Australia.

At the industry level we first examined South Africa's exports in terms of the relevant industry's output followed by industry exports in terms of the total export basket of South Africa. Either way, the overriding observation remains that resources and related activities such as basic metals and basic chemicals are the key driver of South African exports with some diversification into added value activities such as machinery and transport equipment. Although there are signs of further diversification elsewhere they are limited to industries with very low shares, including catering and accommodation. Agriculture is an exception in that its share is now up to 4% of South Africa's export basket, but this has been offset to some degree by a decline in the exports of food products.

Trade involves exports as well as imports and an often-used measure of exposure to trade is the ratio of the sum of exports and imports to what is produced locally. Imports and their prices can be important for exports and here we refer to imports as intermediate imports by those industries that can be identified in the data, i.e., imports of production inputs. It was shown that the industries that are most trade-intensive are not only mining and heavy industries, but now also include other more diversified industries. The main message from the analysis with intermediate imports is that the trade intensity of important industries such as coal mining and motor vehicles is now much lower in the industry ranking while machinery and equipment producers have become more exposed.

One step further and based on direct and indirect intermediate imports (using input-output tables) we can get an impression of 'trade exposure' induced by the vertical integration of production and how intermediate imports are used downstream. However, the results still presents the usual suspects as those industries that are exposed to trade more than average. They include mining, basic metals, machinery, chemicals, oil refining and related activities but now also include more high tech industries such as professional and scientific equipment and TV and electronics. Tertiary industries are less exposed even when taken indirect intermediate imports into account.

Basic metals and basic chemicals see their exposure increase somewhat while they reported significant declines when the measure was just based on direct imports only. This means that these industries have, through their backward linkages, become more exposed to trade, in particular through their imports. The opposite is, to some degree, the case of machinery and electronics equipment as well as paper. What the energy intensity of these and other industries is will be discussed in the next section.

2.2 Energy-intensive sectors of the economy

2.2.1 Introduction

The focus of this section is to employ recent practice in identifying energy-intensive sectors in an economy. One such measure is that of energy demand per unit of economic output (Neuhoff, 2009). This research highlights sectors that warrant special attention in terms of a sectoral approach to climate change mitigation.

For South Africa, Winkler and Marquard (2009b) propose a number of short-term and long-term means of moving the South African economy towards a low-carbon path. In the short term, enhanced energy efficiency can provide energy savings and revenue which can be redistributed towards consumers and companies. In the long term, a move away from the minerals-energy complex towards a low-carbon economy would involve amongst other things, a shift in the fuel mix. Overall, the starting point to selecting economic tools and policy programmes to mitigate climate change is the identification of the energy-intensive sectors of the economy.

It is useful to mention here that energy-intensity and emissions-intensity are related but distinctly different. In particular, it is possible to imagine situations in which energy-intensity (measured as energy demand per unit of economic output) remains unchanged, while emissions intensity (measured as emissions per output) changes; for example, by changing the fuel mix. In the immediate term, it is not expected that South Africa will undergo a great shift in the fuel mix and so in this report energy-intensity can still act as a reasonable first approximation of emissions intensity.

In South Africa the industrial sector is the largest user of energy in final energy demand (Winkler *et al*, 2006). This section of the report aims to highlight the most energy-intensive industrial sectors of the economy as it is pivotal in addressing some of the concerns associated with the Bali Action Plan

(BAP) as stipulated in para 1.b (vi). In particular, at the climate negotiations in August 2009 (so-called 'Bonn3'), South Africa made an intervention on behalf of the Africa group on the issue of economic diversification in the Bali Action Plan, para 1.b(vi). South Africa highlighted 'the broad nature of this particular issue, and that all of it touches Africa from loss of livelihood due to the practice of 'food miles' in Annex 1 countries, through to the loss of export markets, through for example, the threat to a country like Kenya of not being able to sell cut flowers into international markets.' The statement further emphasised the priority that needs to be given to economic diversification applied to adaptation to the adverse effects of climate change, which is a distinct issue from impacts of mitigation measures on developing countries.

2.2.2 Overview of energy in South Africa and recent trends

Primary energy supply in South Africa is predominantly made up of coal, which is abundantly available. Other primary supply sources include crude oil which is largely imported, natural gas, nuclear (facilitated by the abundance of uranium reserves), hydro and renewables (comprising biomass and replenish-able natural processes) (DME, 2006). Table 2.7 indicates that three main primary energy supply sources for the period 2001 and 2006 were coal, crude oil and renewables.

Table 2.7: Total primary energy supply (%)
Source: Own calculations based on DME, Aggregate Energy Balances, 2001 – 2006

Energy supply source	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Average*
Coal	77.2	63.9	72.7	68.2	71.9	67.2	70.2
Crude oil less petroleum	11.4	22.0	13.7	19.4	14.3	20.2	16.8
Gas	2.1	1.8	1.1	1.6	3.0	2.9	2.1
Nuclear	2.9	2.8	3.1	2.8	2.4	2.0	2.7
Hydro	0.2	0.2	0.1	0.1	0.1	0.2	0.1
Renewables	6.0	9.2	9.5	8.2	8.4	7.7	8.2
Total (Terajoules)	3 972 681	4 637 437	4 507 518	5 240 908	5 078 962	5 536 070	28 973 576

Energy demand in South Africa is dominated by the industrial, residential and transport sectors, as shown in Table 2.8 below. Most significantly this demand is attributed to the industrial sector, which together with mining consumed an average of 42% of energy over the period of 2001 to 2006 (as shown in Figure 2.2). The notable fact that energy supply and demand do not equate is attributable to losses in transformation whereby some energy is lost as it is being converted.

Table 2.8: Sectoral energy demand (%)
Source: Own calculations based on DME, Aggregate Energy Balances, 2001 – 2006

Sector	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Industry (excl. mining)	36	35	34	36	33	32
Commerce	6	6	7	8	8	9
Residential	18	18	18	18	18	19
Mining and quarrying	8	8	7	7	8	7
Transport (inc. aviation)	27	27	26	26	26	27
Agriculture	3	3	3	3	3	3
Non-specified (other)	1	1	3	3	4	3
Non-energy use	1	1	1	1	1	1
Total (Terajoules)	2 328 443	2 367 889	2 480 589	2 717 860	2 701 220	2 716 381

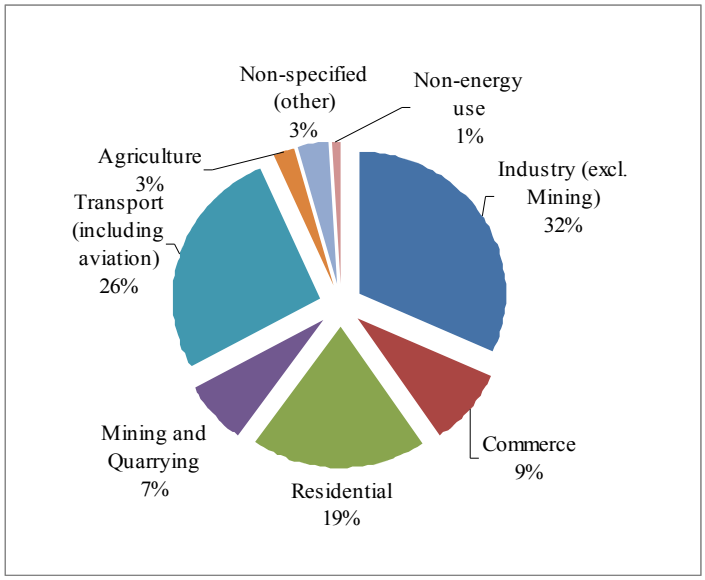


Figure 2.2: Energy demand per sector in 2006
Source: Own calculations based on DME, Aggregate Energy Balances, 2006

2.2.3 How do we identify an energy-intensive sector of the economy?

2.2.3.1 Background to energy demand and GDP data and trends

The focus of this section of the report is on trends in energy intensity in industry, for which trends over in the period 2001–2006 are examined. The time-frame is determined by data availability, with energy data sourced from the then Department of Minerals and Energy (DME), annual aggregate energy balances and GDP figures from Statistics South Africa's Third Quarter GDP data release. The energy balances are only available at a disaggregated sectoral scale up to the end of 2006. This provides a six-year longitudinal view of industry dynamics in terms of energy demand. Measuring the energy intensity of a sector can be achieved in a number of ways including as energy demand per value added, gross value output, and mass of product basis (Hughes et al, 2002:1). Much of the literature identifies an energy-intensive sector as one for which there are 'high energy to output ratios' (Mongia et al, 2001). The DME measured the national energy intensity of the economy during the period from 1993 to 2000 as, total energy demand (in petajoules) divided by GDP (in billions of rands) (DME 2003).

Industry in South Africa has shifted from being mining-intensive to energy-intensive manufacturing processes (Hughes *et al*, 2002). This trend is shown in Table 2.9, where the manufacturing sector contributed on average 0.6% to the total real annual economic growth rate over the period of 1998 to 2007. The FRIDGE study similarly identifies South Africa as deriving its wealth from energy-related activities (Consult 101 *et al*, 2001: xvi). This characteristic of the economy is described by Fine and Rustomjee (1996) as the minerals-energy complex. Given that industry comprises the largest users of energy in South Africa we continue reporting on industry which is a sub-set of the entire economy, is assessed in terms of trends in energy-intensity between 2001 and 2006.

Table 2.9: Contributions to the total real annual economic growth rate (percentage points)
Source: SSA (2008: Table B)

Industry	*Relative size 2007 (percent)*[1]	*Real annual percentage change for 2005 (compared with 2004), 2006 (compared with 2005) and 2007 (compared with 2006)*									*Contributions to the total real annual economic growth rate (percentage points)* [2]								
		1998	*1999*	*2000*	*2001*	*2002*	*2004*	*2005*	*2006*	*2007*	*1998*	*1999*	*2000*	*2001*	*2002*	*2004*	*2005*	*2006*	*2007*
Agriculture, forestry and fishing	2.3	-5.3	6.2	4.7	-3.3	6.5	1.4	5.4	-7.2	2.9	-0.2	0.2	0.1	-0.1	0.2	0.0	0.1	-0.2	0.1
Mining and quarrying	5.8	-0.1	-1.4	-1.1	-0.1	1.0	1.3	2.2	-0.3	0.0	0.0	-0.1	-0.1	0.0	0.1	0.1	0.1	0.0	0.0
Manufacturing	16.3	-0.2	0.6	8.1	3.2	2.8	4.7	4.6	4.9	4.5	0.0	0.1	1.3	0.5	0.5	0.8	0.8	0.8	0.7
Electricity, gas and water	2.1	-6.3	-0.5	3.1	-3.7	3.5	3.0	1.7	2.8	3.0	-0.2	0.0	0.1	-0.1	0.0	0.1	0.0	0.1	0.1
Construction	3.0	-5.9	-1.4	5.6	4.9	5.8	11.1	12.4	13.5	17.1	-0.1	0.0	0.1	0.1	0.1	0.3	0.3	0.4	0.6
Wholesale and retail trade; hotels and restaurants	14.1	1.3	7.6	8.1	1.9	2.3	5.9	7.3	7.2	5.2	0.2	0.9	1.0	0.3	0.1	0.8	1.0	1.0	0.7
Transport, storage and communication	9.9	5.5	5.2	8.3	5.9	9.0	4.7	5.3	6.6	5.6	0.4	0.4	0.7	0.5	0.9	0.5	0.5	0.7	0.6
Finance, real estate and business services	19.4	2.3	5.1	3.2	8.2	6.3	7.9	5.2	7.2	6.8	0.4	0.9	0.5	1.4	1.1	1.5	1.0	1.4	1.3
General government services	12.6	-0.7	-0.9	-0.9	-0.9	0.7	2.6	3.1	3.1	3.7	-0.1	-0.1	-0.1	-0.1	0.1	0.3	0.4	0.4	0.5
Personal services	5.4	8.9	7.7	9.1	1.5	2.5	2.0	4.4	5.8	4.0	0.2	0.2	0.3	0.0	0.1	0.1	0.2	0.3	0.2
Total value added	*91.0*	0.7	*2.7*	*4.4*	*2.9*	*3.8*	*4.8*	*5.0*	*5.2*	*5.1*	0.6	2.4	4.0	2.5	3.2	4.4	4.6	4.7	4.7
Taxes less subsidies on products	8.9	-1.2	-0.6	1.5	1.4	2.7	5.3	4.7	6.1	4.7	-0.1	-0.1	0.1	0.1	0.4	0.5	0.4	0.6	0.4
GDP at market prices	100.0	0.5	2.4	4.2	2.7	3.7	4.9	5.0	5.3	5.1	0.5	2.4	4.2	2.7	3.7	4.9	5.0	5.3	5.1

1. The relative size of each industry for the year 2007 is the share of its real value added of the GDP for the year 2006. Similarly, the relative size of taxes less subsidies on products is the share of its value of the GDP for the year 2006.

2. The contribution is calculated by multiplying the percentage change of each industry (and taxes less subsidies on products) with its share of GDP in the previous year (i.e. its relative size).

2.2.3.2 Measuring energy-intensity across a sub-sector of the economy

In this report, energy intensity is measured as energy demand (in terajoules) per unit of GDP (in millions of 2000 constant rands). As such, the data used to derive a measure of energy intensity are energy demand per sector and GDP (total output) per sector. Energy intensity is then calculated as energy demand per sector, divided by economic output of that sector.

Table 2.10 and Figure 2.3 show the trends in energy demand per sector between 2001 and 2006. Most notable is that the top six energy consuming industrial sectors include iron and steel, chemical and petrochemical products, mining and quarrying, non-ferrous metals and non-metallic minerals. In the case of these first three sectors we see a close alignment with the findings of Hughes *et al* (2002).[10]

Table 2.10: Energy demand per industrial sub-sector in Terajoules, (%)
Source: Own calculations based on DME, Aggregate Energy Balances, 2001 – 2006

Industrial sub-sector	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Average*
Iron and steel	277 078 (27.1)	280 727 (27.4)	292 005 (28.2)	313 771 (26.7)	305 487 (27.6)	293 426 (27.4)	293 749 (27.4)
Non-specified (industry)	193 139 (18.9)	239 165 (23.4)	232 777 (22.5)	350 907 (29.9)	280 190 (25.3)	282 522 (26.3)	263 117 (24.4)
Mining and quarrying	183 744 (18.0)	183 795 (18.0)	180 699 (17.5)	190 274 (16.2)	204 592 (18.5)	201 982 (18.8)	190 848 (17.8)
Chemical & petrochemical	235 000 (23.0)	184 584 (18.0)	178 524 (17.2)	154 006 (13.1)	141 809 (12.8)	147 625 (13.8)	173 591 (16.3)
Non-ferrous metals	56 974 (5.6)	58 043 (5.7)	58 530 (5.7)	64 630 (5.5)	67 104 (6.1)	67 106 (6.3)	62 065 (5.8)
Non-metallic minerals	43 406 (4.2)	43 944 (4.3)	59 019 (5.7)	67 349 (5.7)	74 818 (6.7)	44 867 (4.2)	55 567 (5.2)
Construction	15 044 (1.5)	15 816 (1.5)	16 939 (1.6)	15 982 (1.4)	16 535 (1.5)	15 665 (1.5)	15 997 (1.5)
Paper pulp and print	8 835 (0.9)	8 837 (0.9)	7 777 (0.8)	7 697 (0.7)	8 635 (0.8)	9 441 (0.9)	8 537 (0.8)
Food and tobacco	3 724 (0.4)	3 785 (0.4)	3 688 (0.4)	3 516 (0.3)	3 783 (0.3)	4 135 (0.4)	3 772 (0.4)
Textile and leather	1 774 (0.2)	1 901 (0.2)	1 880 (0.2)	1 890 (0.2)	1 868 (0.2)	1 868 (0.2)	1 864 (0.2)
Machinery	1 010 (0.1)	1 019 (0.1)	2 337 (0.2)	2 071 (0.2)	2 278 (0.2)	2 479 (0.2)	1 865 (0.2)
Wood and wood products	1 011 (0.1)	1 115 (0.1)	974 (0.1)	1 044 (0.1)	1 068 (0.1)	1 069 (0.1)	1 047 (0.1)
Transport equipment	682 (0.1)	717 (0.1)	343 (0.0)	304 (0.0)	332 (0.0)	329 (0.0)	451 (0.0)
Total	1 021 419	1 023 448	1 035 492	1 173 440	1 108 500	1 072 513	100

[10] Figure A.1 in the Appendix highlights the trends of the other seven main industrial energy consuming sectors.

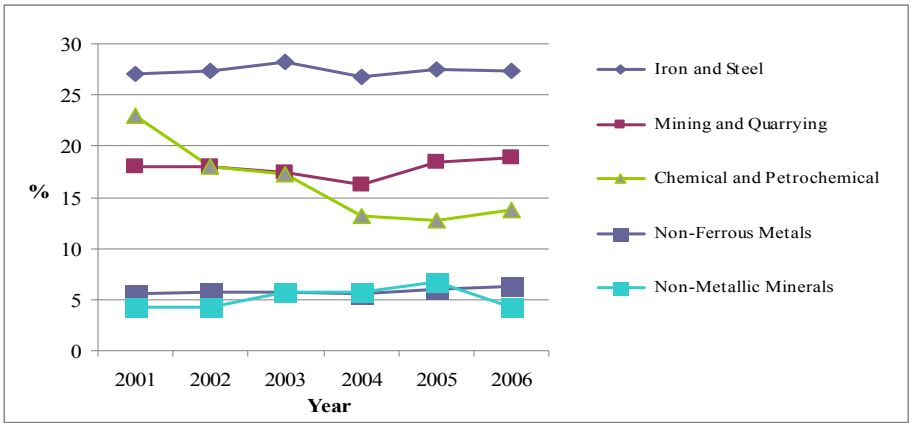


Figure 2.3: Trends in GDP across industrial sub-sectors, 2001 to 2006
Source: Own calculations based on DME, Aggregate Energy Balances, 2001 – 2006[11]

In terms of output in each of these industrial sectors Table 2.11 and Figure 2.4 indicate that, much as expected, the mining and quarrying sector as well as chemical and petrochemical products and iron and steel (inclusive of non-ferrous metals in SSA GDP figures) contribute significantly to GDP of the industrial sectors assessed. Close followers include the construction and food and tobacco industries. The construction industry showed a notable increase in GDP during the 2001 to 2006 time period whereas the mining and quarrying sector appeared to decline in output between 2003 and 2006.

Table 2.11: Annual GDP per industrial sub-sector in constant 2000 prices - Rmillion, (%)
Source: SSA, 2001 – 2006

Industrial sub-sector	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Average*
Non-metallic minerals	4 989	5 470	5 446	5 576	5 806	5 933	5 537
	(1.8)	(1.9)	(1.9)	(1.8)	(1.8)	(1.8)	(1.8)
Iron & steel & Non-ferrous metals	30 875	34 777	34 456	36 086	37 832	38 667	35 449
	(11.0)	(12.0)	(11.8)	(11.9)	(11.8)	(11.6)	(11.7)
Chemical and petrochemical	40 140	39 550	39 478	40 675	41 553	43 362	40 793
	(14.3)	(13.6)	(13.5)	(13.4)	(13.0)	(13.0)	(13.5)
Mining and quarrying	63 325	63 927	66 502	67 363	68 818	68 591	66 421
	(22.6)	(22.0)	(22.8)	(22.1)	(21.5)	(20.5)	(21.9)
Construction	22 154	23 441	25 053	27 830	31 268	35 494	27 540
	(7.9)	(8.1)	(8.6)	(9.1)	(9.8)	(10.6)	(9.0)
Wood & paper, publishing & printing	16 605	16 614	16 381	17 447	18 725	20 824	17 766
	(5.9)	(5.7)	(5.6)	(5.7)	(5.9)	(6.2)	(5.8)
Machinery	5 133	5 079	5 084	5 104	5 636	6 246	5 380
	(1.8)	(1.7)	(1.7)	(1.7)	(1.8)	(1.9)	(1.8)
Textile & leather	7 503	8 108	7 919	8 599	8 279	8 262	8 112
	(2.7)	(2.8)	(2.7)	(2.8)	(2.6)	(2.5)	(2.7)
Food & tobacco	25 582	26 094	24 990	25 847	27 575	28 952	26 507
	(9.1)	(9.0)	(8.6)	(8.5)	(8.6)	(8.7)	(8.7)
Transport equipment	16 134	15 925	15 271	16 337	17 469	18 406	16 590
	(5.8)	(5.5)	(5.2)	(5.4)	(5.5)	(5.5)	(5.5)
Total GDP across these industries	279 920	290 377	291 417	304 398	319 517	334 229	100

[11] Non-specified industry comprises one of the six highest energy consuming sectors but is omitted from this discussion as it does not comprise a single sector to which later analyses can easily be compared.

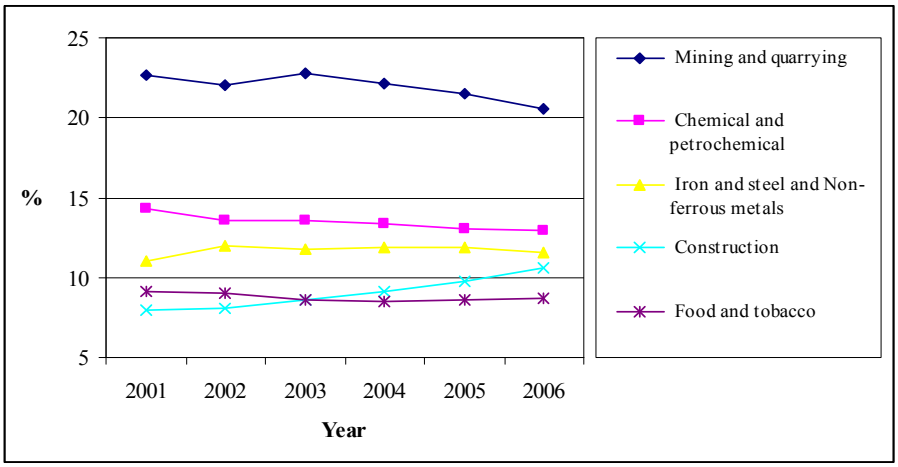


Figure 2.4: Trends in GDP across industrial sub-sectors, 2001 to 2006[12]
Source: Own calculations based on SSA, 2001 – 2006

Next we combine the above. Table 2.12 shows energy intensity by industry as energy use **per unit of economic output**.[13] While there were movements in the trend of energy-intensity, in general, the data shows a decline which could be explained by variation in the data reported in the energy balances as most industries record positive growth. It is immediately clear that the most energy-intensive sectors are non-metallic minerals, iron and steel, chemical and petrochemical products, mining and quarrying,[14] and non-ferrous metal as ranked by average energy-intensity (most to least) for the period 2001 and 2006, portrayed in Figure 2.5.

Table 2.12: Energy intensity (energy per economic unit of output)
Energy demand (Terajoules)/GDP (constant 2000 prices - Rmillion)
Source: Own calculations based on DME, Energy Balances data and SSA (2008)

Industrial sub-sector	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Rank*
Iron and steel and non-ferrous metals	10.8	9.7	10.2	10.5	9.8	9.3	1
Non-metallic minerals	8.7	8.0	10.8	12.1	12.9	7.6	2
Chemical and petrochemical	5.9	4.7	4.5	3.8	3.4	3.4	3
Mining and quarrying	2.9	2.9	2.7	2.8	3.0	2.9	4
Construction	0.7	0.7	0.7	0.6	0.5	0.4	5
Paper pulp and print and wood	0.6	0.6	0.5	0.5	0.5	0.5	6
Machinery	0.2	0.2	0.5	0.4	0.4	0.4	7
Textile and leather	0.2	0.2	0.2	0.2	0.2	0.2	8
Food and tobacco	0.1	0.1	0.1	0.1	0.1	0.1	9
Transport equipment	0.0	0.0	0.0	0.0	0.0	0.0	10

[12] The trends in GDP across the other main industrial sub-sectors are shown in Figure A.2 in the Appendix.

[13] Ideally 'sector-specific' information should be used to assess the energy efficiency of sectors to ensure the drivers behind the changes we see, are explained. In this report we do not attempt to explain the drivers of changes in energy-intensity and thus this approach is not necessary.

[14] The gold mining sector is a particularly energy-intensive sector, as the deeper gold is needed to be mined the more energy is required to make this possible.

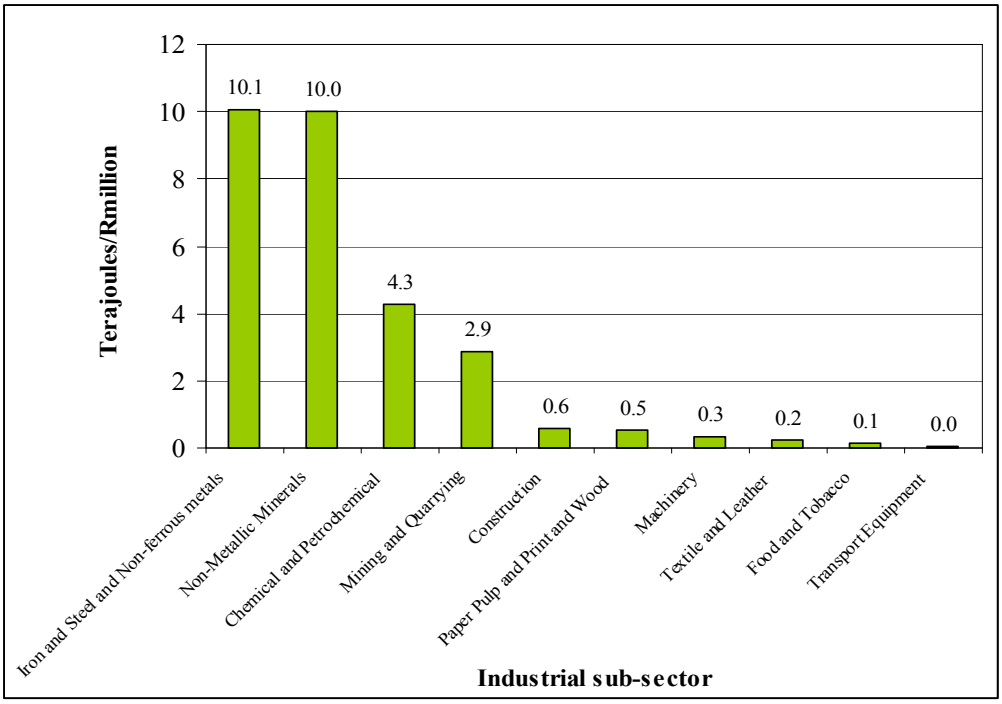


Figure 2.5: Average energy intensity between 2001 and 2006 across industrial sectors
Source: Own calculations based on DME, Energy Balances data and SSA (2008)

A comparison of Tables 2.11 and 2.12 would suggest that the industry sub-sectors of highest energy intensity did not appear to experience any dramatic changes in output over the 2001 to 2006 time period. However, it is clear that while for example, the decline in energy demand observed in Table 2.10 for the chemical and petrochemical sector is associated with an increase in output for this sector. This suggests that the chemical and petrochemical sector may have 'cleaned its act' between 2001 and 2006.

2.2.4 Summary

This section has assessed recent trends of energy demand and the energy intensity of the industrial sector in South Africa. In regard to the latter, only energy intensity in the industrial sector was examined as this sector comprises the largest users of energy in South Africa. The energy-intensity metric used to identify these sectors was that of energy demand (in terajoules) per unit of GDP (in millions of 2000 constant rands). A comparison across sectors showed that the top four sectors of 'high energy to output' ratios' were:

1. iron and steel and non-ferrous metals.
2. non-metallic minerals;
3. chemicals and petrochemicals;
4. mining and quarrying; and

These top-four energy-intensive sectors stand-out from the remaining industrial sectors. An analysis of trends in energy-intensity over the period 2001 to 2006 suggests that there may be declining energy intensity. This could be due to issues in the underlying data, or a real effect. The possible explanations of this would include that of a move to more tertiary sectors and a service economy. The other possibility would be that some energy efficiency measures are having an impact. Further analysis and longer, more consistent time-series would be needed to confirm any such trend definitively.

2.3 Identifying the energy-intensive and trade-exposed sectors of the economy

The preceding sections have assessed the South African economy to determine those industries which are most energy-intensive *and* trade-exposed. Section 2.1 indicated that there is some limited evidence of a shift to non-traditional trade. Basic metals still drive exports but with some diversification into chemicals, machinery and transport equipment and resource-intensive sectors remain important. Section 2.2 showed that the most energy-intensive sectors of the South African economy are non-metallic minerals, basic metals, chemical and petrochemical products, and mining and quarrying. A comparison of Tables 2.5 and 2.11 show that the most important trade-exposed sectors of the South African economy are gold and uranium ore mining, metals (ferrous and non ferrous), leather and leather products, other mining, basic chemicals, machineries and equipment, coal mining; while the most important energy-intensive sectors (most of which are also trade-exposed) are non-metallic minerals, iron and steel, chemical and petrochemical, mining and quarrying, non-ferrous metals, machinery, textile and leather, food and tobacco, wood and wood products, and transport equipment.

A combination of these two lists thus will indicate that those sectors that are trade-exposed (TE) or trade-intensive as well as being energy-intensive (EI) provide a list of energy-intensive and trade-exposed (EITE) sectors. The methodology used for this report has been to use expert judgement, in considering the rankings for EI and TE sectors. Table 2.13 below provided the basis for this comparison. Future research could fully align sectors across the various datasets used for such purposes. The five top EITE sectors in South Africa are identified in this study as:

1. basic iron and steel;
2. non-ferrous metals;
3. chemicals and petrochemical products;
4. mining and quarrying (including coal);
5. machineries and some other manufactures (such as food products, as well as transport vehicles and equipment.

Unsurprisingly these are similar sectors to those identified in other countries facing the same policy dilemmas. Transport as a service sector is highly energy intensive. However, often transport (and trade) is considered only as a 'margin', i.e. as a means to facilitate production and exchange, hence it may not feature directly as a single 'sector'. Air transport is also a component of international tourism which is an important trade-related or export sector (see Section 3 below). Hence the list of energy-intensive trade-intensive sectors may also include transport:

6. transport services including air transport.

In general, with the onset of new climate policies post-Copenhagen, it is the energy-intensive and trade-exposed sectors of the economy which could be most threatened in terms of international competitiveness.

Table 2.13: Energy-intensive and trade-exposed sectors

Trade-exposed	*Energy-intensive*	*Energy-intensive and trade-exposed*
Mining, Basic metals (ferrous and non-ferrous metals)	Basic metals (iron and steel and non-ferrous metals)	Basic iron and steel
Machinery	Non-metallic minerals	Non-ferrous metals
Chemicals	Chemical and petrochemical products	Chemicals and petrochemicals
Oil Refining and related	Mining and quarrying	Mining and quarrying (incl. coal)
High tech industries (professional and scientific equipment and TV electronics)		Machineries and manufactures (incl. food products and transport vehicles and equipment)
		Transport services including air transport

3. Implications for South African trade of different climate change policy scenarios

3.1 Defining the scenarios

To study the impacts of response measures to climate change on South African trade-related sectors, we conduct a number of policy simulations based on various scenarios. These scenarios are based on trade relations between South Africa and the rest of the world in which there will be carbon constraints on Annex I countries, but assuming there are no constraints on emissions for South Africa (nor for other non-Annex I (NAI) countries). The scenarios include:

- Scenario 1: Reductions by Annex I countries of 25% below 1990 levels by 2020. There are three variations under this scenario:
    - 1A: No ET ('No emissions trade'): assuming there are no emissions trading amongst Annex I countries (but emissions trading only within each Annex I country)[15]; this provides a benchmark to measure marginal abatement costs (MACs) of different Annex I countries and regions,
    - 1B: Annex I ET ('Annex I emissions trade'): Annex I countries can trade in emissions reduction with each other, [16] but not with NAI countries, nor can Annex I countries buy emissions reduction credit from NAI countries.
    - 1C: Annex ET with NAI no-lose crediting ('Annex I emissions trade with NAI emissions reduction no-lose crediting'): Annex I countries can trade emissions reductions with each other as well as buying emissions reduction credits from NAI countries to offset their non-reduction.[17]
- Scenario 2: Reductions by Annex I countries of 40% below 1990 levels by 2020. The purpose of this scenario is to test the sensitivity and robustness of the results under Scenario 1. Hence the same three variations 2A, 2B, 2C will be repeated here.

3.2 Methodology and data

The scenario simulations are conducted using the GTAP-E comparative static general equilibrium model. This model has been adapted to produce results for several periods by means of a recursive dynamic method. By recursive dynamic method, we mean that the results of one period are used to update the database for the next period, and then a simulation for the next period is repeated under different circumstances which reflect changing conditions for the next period.[18] The database used for the simulations are based on the GTAP version 7 database which has economic, energy, and emissions information for 113 countries/regions and relating to 57 different economic sectors. For the purpose of this study, the regions and sectors are aggregated into a 20 by 20 data set with 20 aggregated regions and 20 aggregated sectors.[19] Because the focus of the study is on the effect of response measures of Annex I countries to climate change on South African trade, especially in the

---

15 This can also be referred to as 'domestic' emissions trading. Without domestic emissions trading it would be much more expensive to arrive at a particular (domestic) emissions reduction target hence this situation is not considered.

16 Quite clearly, this would include emissions trading within each Annex I country because it would not be meaningful to allow trade between Annex I countries while not allowing for the same trade within each country.

17 Proposals for various sectoral approaches have been made in the negotiations, both under the AWG-KP and the AWG-LCA. The KP has considered sectoral crediting and sectoral trading (e.g. http://unfccc.int/resource/docs/2009/awg9/eng/10a02.pdf), while in the LCA subgroup on paragraph 1 (b) (iv) of the Bali Action Plan has produced non-paper 43, 'Cooperative sectoral approaches and sector-specific actions', see http://unfccc.int/meetings/ad_hoc_working_groups/lca/items/5012.php South Africa has indicated in the negotiations that, among the variety of sectoral approaches, it finds no-lose sectoral crediting baselines a conceptually interesting option to creatively extend carbon markets, but its political feasibility must be further explored.

18 More details on this methodology are given in the Appendix.

19 See Appendix 2.

energy-intensive production and consumption sectors, we aggregated the sectors in such a way that it can relate to the set of energy intensive and trade-exposed (EITE) sectors of South Africa's economy that have been identified in Section 2 above. Table 3.1 provides information on the EITE sectors based on the GTAPv7 database.

By way of introduction it is useful to consider the importance of exports and imports (for a particular sector) from the GTAP-E perspective so as to confirm the findings in the earlier section. We do this not only relative to the size of *its own production* (see Section 2.1) which is used to create column 5 labelled 'SASID rank' reported in Table 3.1, but also relative to the total value of exports or imports of the *whole economy* (as indicated by columns 3 and 4 of Table 3.1 with the labels GTAP export and GTAP import 'rank'). Next, column 5 of Table 3.1 shows the energy intensity of the sectors based on GTAP energy input data [in million tons of oil equivalent (toe)] and economic output value data (in 2004 $ million). This information is used to provide the GTAP energy intensity rank listed in column 7). From Table 3.1, the most important 'trade-intensive' sectors according to the GTAP export/import ranks and SASID rank are: 'Agriculture, forestry, fishery, food beverages and tobacco products', 'Minerals not elsewhere classified (nec).', 'Chemical, rubber, and plastics', 'Iron and steel', 'Non ferrous metals', 'Motor vehicle, spare parts, and transport equipment', 'Other manufacturing'. The most energy-intensive sectors according to the GTAP rank are: 'Minerals nec.', 'Chemical, rubber, and plastics', 'Non-metal mineral nec', 'Iron and steel', 'Non-ferrous metals', 'Air transport', and 'Trade and other transport'. The last two sectors can be referred to as consumption-oriented sectors, in contrast to the first five sectors which are primarily production-related. There are thus overlaps between the two sets which produce the following set of 'energy-intensive trade-exposed' (EITE) sectors:

- 'Minerals nec.';
- 'Chemical, rubber, and plastics';
- 'Iron and steel', 'Non ferrous metals', 'Ferrous metal products';
- 'Trade and transport'.

The rest are either trade-intensive or energy-intensive but not both. For example, 'Coal mining' and 'Agri., forest., fish., food bev. and tobacco' are seen to be important trade-exposed sectors but not energy-intensive. 'Motor vehicle, spare parts, transport equipment', as well as 'Other manufacturing' (which includes other machineries) do not feature strongly in GTAP-E energy-intensive list. This is consistent with Table 2.11 and Figure 2.4 of Section 2, where machinery and manufacture cannot be counted as energy-intensive when compared against highly energy-intensive sectors such as iron and steel, but are energy-intensive in any case. Thus, in order for the list of GTAP sectors used for purpose of our simulation study, to be consistent with our earlier focus on EITE sectors it is 'expanded' to include these sectors. Finally, 'Air transport' is highly energy-intensive (as expected and shown in GTAP list of EI sectors) and although it is not listed as a trade-exposed sector in Section 2, it is included in the list of EITE sectors because firstly, it is a component of the 'International tourism' sector (discussed below) and also since air transport, like any other forms of transport, is a 'margin' which is used in most trade activities.

Table 3.1: Trade intensities of South African sectors in 2004
Source: GTAP v7, Quantec

					1	2	3	4	5	6	7
No.	*Description*	*TE*	*EI*	*EITE*	*GTAP total imports at market prices (m 2004 $)*	*GTAP total exports at world prices (m 2004 $)*	*GTAP import rank*	*GTAP export rank*	*SASID trade-exposure rank*	*GTAP energy intensity (toe/ $mill)*	*GTAP energy intensity rank*
1	***Coal***	TE			3 801.4	3 101.4	8	8	9		
2	Oil				0.0	0.0	20	20	6		
3	Gas				0.2	0.2	19	19	7		
4	Refined products				1 485.5	1 243.2	11	12	10		
5	Electricity				273.3	273.3	18	18	18		
6	***Agri. forest. fish. food bev. tobacco.***	TE			7 378.2	6 367.3	3	3	13	51	11
7	**Minerals nec**	TE	EI	EITE	5 659.6	5 244.4	5	5	1	814	1
8	Paper products, publishing				1 399.6	1231.2	12	13	11	58	10
9	**Chem., rubber, *plastic products***	TE	EI	EITE	5 294.3	4 865.7	6	7	8	205	6
10	**Non metal minerals nec**		EI		622.6	544.1	17	17	14	654	2
11	**Iron and *steel***	TE	EI	EITE	6 336.7	5 921.3	4	4	2	483	4
12	**Non ferr*ous metals***	TE	EI	EITE	9 583.3	9 486.3	2	1	3	211	5
13	***Ferrous metal products***	TE	EI	EITE	1 202.1	1 103.3	14	14	4	60	9
14	***Motor veh. & parts, trans. equip.***	TE		EITE	5 244.9	4 977.2	7	6	12	5	15
15	***Other manufacturing***	TE		EITE	9 996.5	9 268.8	1	2	5	24	12
16	**Air transport**		EI	EITE	1 077.3	1 077.3	15	15	15	569	3
17	**Trade & *trans.*(excl. air trans.)**	TE	EI	EITE	2 696.6	2 696.6	9	9	16	153	7
18	Rec., cultural, sport., dom. svces				1 259.1	1 259.1	13	11	17	77	8
19	Other market services				1 805.7	1805.7	10	10	20	23	13
20	Government services				975.7	975.7	16	16	19	12	14
	Total				66 092.5	61 442.0					

** Note: Energy-intensive sectors are shown in bold, trade-exposed sectors in italics.*

Figure 3.1 below reiterates some of the important trade-intensive sectors of the SA economy. In aggregating the SA sectors for the purpose of this study, there is one important 'export' sector which is not easily aggregated: international tourism. Based on the expenditure pattern of international tourists in SA (in the year 2005) taken from the Statistics South Africa Draft Tourism Satellite Accounts (SSA 2005) which is shown in Table 3.2, we can 'reconstruct' an 'International tourism' sector as reported in Figure 3.2. (Some shares may seem large but that is the result of very low export values in the relevant industries). Figure 3.3 below shows the most important regions with which SA has significant trade.

Table 3.2: Components of 'International tourism' sector based on expenditures in 2005

Model code	*Description*	*Share of inbound visitors expenditure of sector's exports*
P_C	Refined products	8%
AFBT	Agriculture, forestry, fishing, food beverages and tobacco	10%
CRP	Chemical, rubber, plastic products	0.2%
OMF	Other manufacturing	23.6%
ATP	Air transport	74.2%
TTR	Trade and transport (excl. air transport)	85.2%
ROS	Recreational and other services	85.2%
OSM	Other market services	91.4%

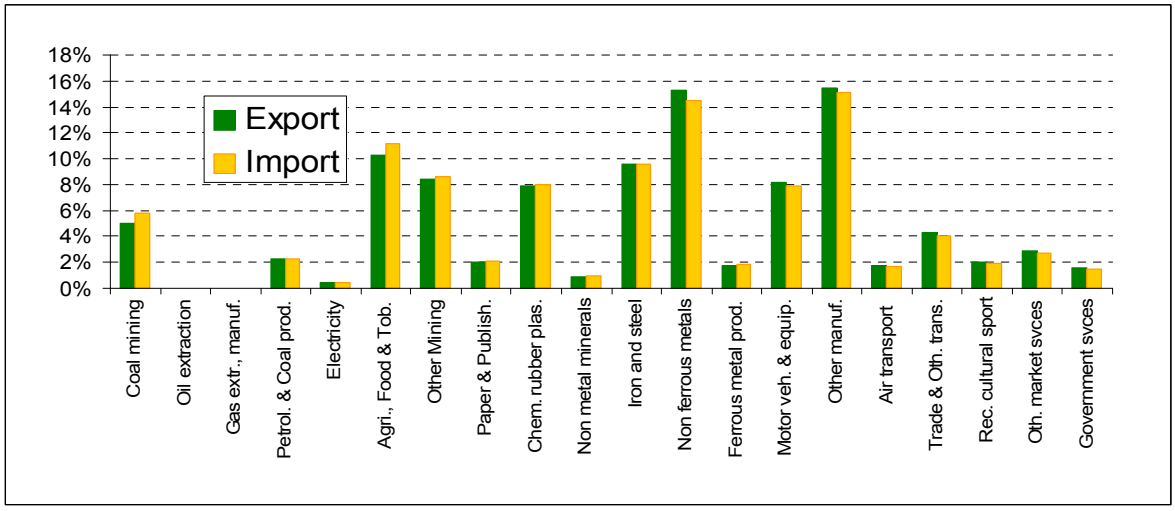


Figure 3.1: South African exports and imports – by sectors (GTAP v7 database, 2004) (% of total)

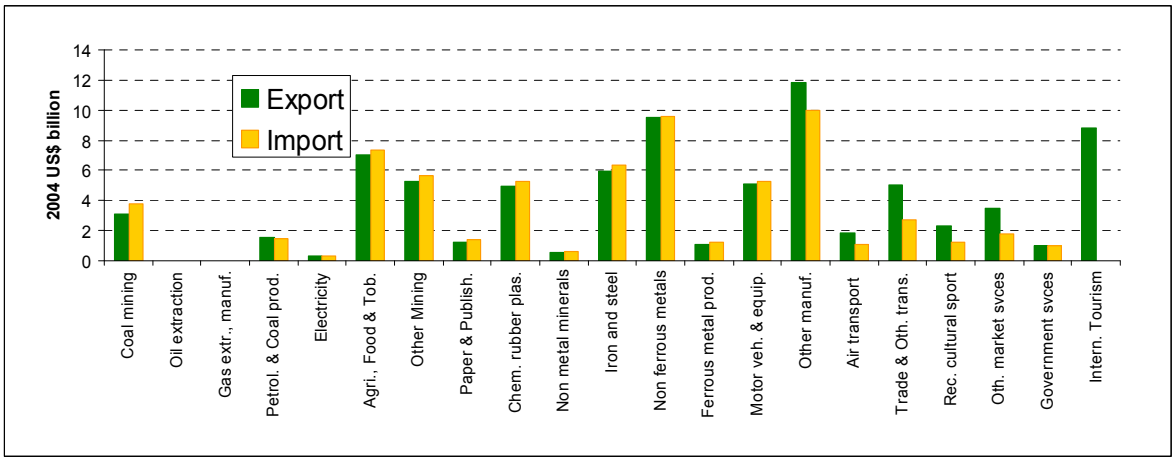


Figure 3.2: South African exports and imports by sectors including international tourism (2004)

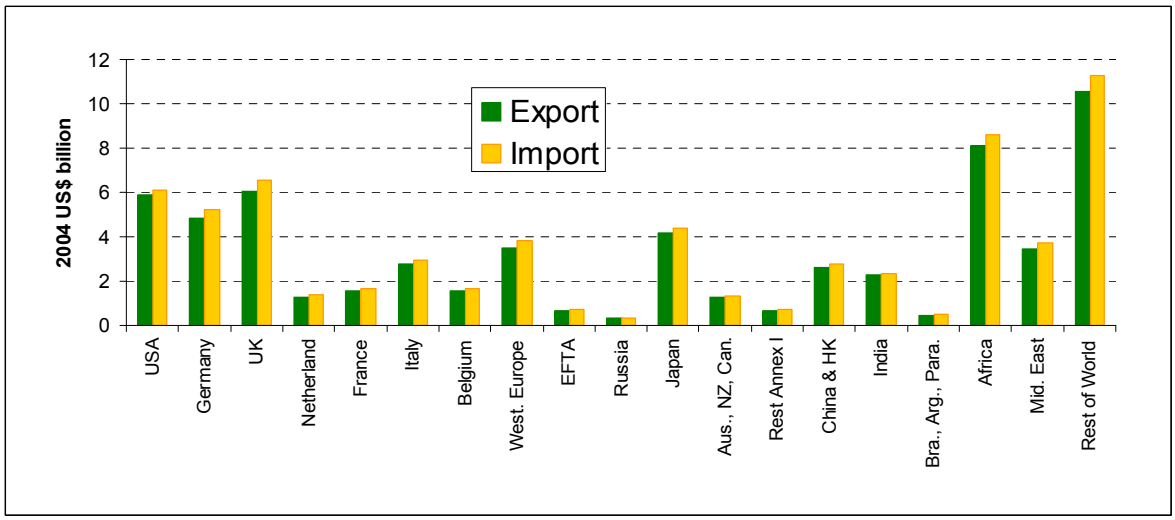


Figure 3.3: South African exports and imports – by regions (GTAP v7 database, 2004)

3.3 Results and findings

3.3.1 Reference or Business as usual Scenario

Since we are conducting simulation experiments into the future, we need to create a baseline which requires some assumptions to be made. To predict the future levels of CO_2 emissions for regions around the world, we need to specify assumptions about the basic drivers of these emissions. The two main drivers we can use in the GTAP-E model are population growth and GDP growth.[20] The assumptions regarding GDP growth rates are based on the IPCC Special Report on emissions scenarios,[21] and the assumptions regarding population growth rates are based the United States (US) Census Bureau projections.[22] The assumptions are listed in Table 3.3 and illustrated graphically in Figures 3.4 and 3.5.

Table 3.3: Assumed basic drivers of CO_2 emissions

		GDP growth (% p.a.)			*Population growth (% p.a)*		
No.	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	2.99	2.83	2.77	0.73	-0.34	0.10
2	USA	2.20	2.11	2.05	1.00	0.99	0.97
3	Germany	1.91	1.84	1.78	-0.03	-0.08	-0.13
4	UK	1.91	1.84	1.78	0.28	0.29	0.29
5	Netherlands	1.91	1.84	1.78	0.47	0.35	0.30
6	France	1.91	1.84	1.78	0.60	0.47	0.37
7	Italy	1.91	1.84	1.78	0.02	-0.14	-0.23
8	Belgium	1.91	1.84	1.78	0.12	0.06	0.02
9	W Europe	1.91	1.84	1.78	0.20	0.10	0.00
10	EFTA	1.91	1.84	1.78	0.40	0.26	0.23
11	Russia	3.63	3.44	3.37	-0.48	-0.49	-0.55
12	Japan	1.91	1.84	1.78	-0.08	-0.33	-0.49
13	Aus., NZ, Canada	2.20	2.11	2.05	1.00	0.93	0.85
14	Rest Annex I	1.91	1.84	1.78	-0.33	-0.32	-0.38
15	China & HK	6.00	5.80	5.00	0.62	0.68	0.53
16	India	5.00	5.00	4.20	1.68	1.51	1.39
17	Bra., Arg., Para.	2.99	2.83	2.77	1.32	1.14	0.99
18	Africa	2.99	2.83	2.77	1.93	2.06	1.79
19	Middle East	2.99	2.83	2.77	1.85	1.70	1.52
20	Rest of world	3.70	3.52	3.43	1.75	1.64	1.55

[20] Other drivers can also be used such as the level of resources (endowments) utilization, such as the rates of growth of labour, capital, land, and natural resources used. If these drivers are chosen then GDP growth will be endogenous. Conversely, if GDP growth rates are chosen as drivers (exogenous), then the rates of resource utilisation will be endogenous.

[21] http://www.grida.no/publications/other/ipcc_sr/?src=/climate/ipcc/emission/.

[22] http://www.census.gov/ipc/www/idb/informationGateway.php.

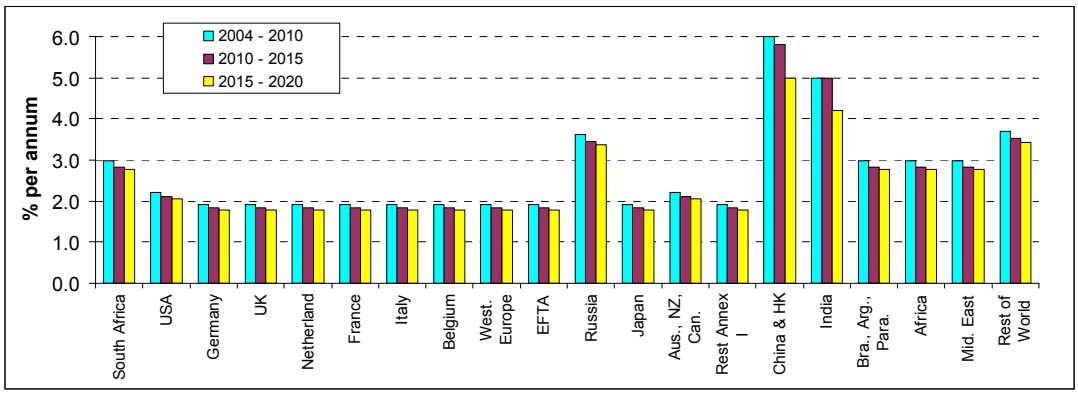


Figure 3.4: Assumed per annum GDP growth rates over the study periods

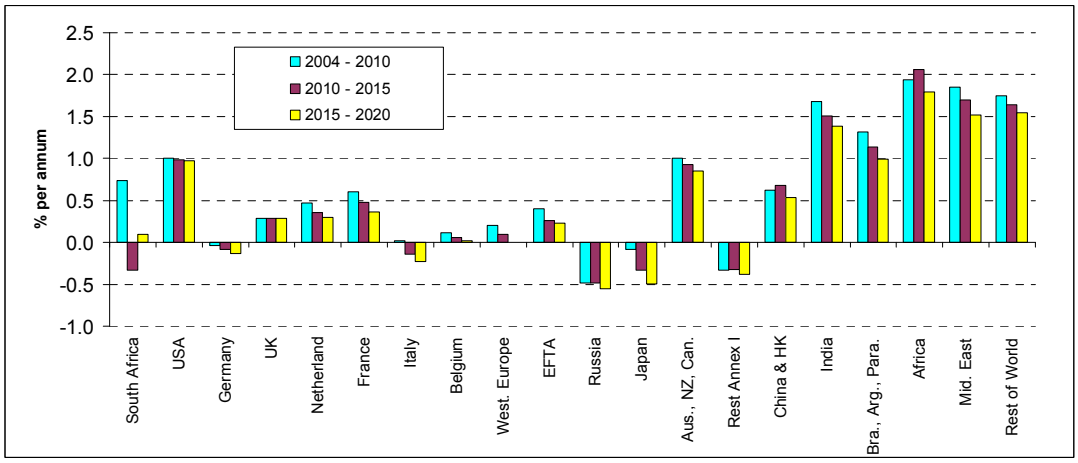


Figure 3.5: Assumed per annum population growth rates over the study periods

Based on these basic assumptions, we run the GTAP-E model to produce a reference or Business-as-usual (BaU) scenario. The emissions levels for the BaU scenario are shown in Table 3.4. From this table, it can be seen that without the imposition of any climate policy around the world, global CO_2 emissions are expected to grow by 19.8%, 16.3% and 15.5% respectively for each period 2004-2010, 2010-2015, and 2015-2020. These trends are reinforced graphically in Figure 3.6 below. The rates of growth of CO_2 emissions for Annex I regions over these periods are lower than the global averages: at 13.8%, 11.0%, and 10.7% respectively. This implies that growth rates of CO_2 emissions for NAI regions are larger than the world average. This reflects to a large extent the fact that NAI regions are generally less energy- and emissions-efficient than Annex I regions, even though to some extent, higher population growth and GDP growth (such as for the case of China and India) also plays a role. Figure 3.7 shows how regions fare in terms of their CO_2 emissions.

Table 3.4: CO_2 Emission in the BaU scenario (million tons of carbon per annum)

No.	*Region*	*1990*	*2004*	*2010*	*2015*	*2020*
1	South Africa		98.16	115.9	132.3	150.7
2	USA	1351.9	1655.33	1881.5	2086.0	2306.7
3	Germany	276.1	216.57	242.3	265.1	289.4
4	UK	159.3	162.17	181.3	198.2	216.3
5	Netherlands	45.7	55.42	62.1	68.0	74.3
6	France	100.0	102.43	115.1	126.4	138.4
7	Italy	117.0	120.75	135.1	147.9	161.5
8	Belgium	30.9	28.06	31.5	34.5	37.8
9	W Europe	223.9	211.01	236.5	259.1	283.3

No.	*Region*	*1990*	*2004*	*2010*	*2015*	*2020*
10	EFTA	22.2	29.95	33.6	36.8	40.3
11	Russia	651.5	423.4	513.2	599.0	697.0
12	Japan	320.0	298.81	335.0	367.2	401.4
13	Aus., NZ, Canada	210.5	260.28	295.6	327.5	361.7
14	Rest Annex I	445.5	358.4	400.0	436.9	476.0
15	China & HK		1219.6	1658.5	2138.5	2672.3
16	India		289.49	376.9	471.3	570.5
17	Bra., Arg., Para.		122.95	144.9	165.3	188.1
18	Africa		20.82	24.7	28.4	32.5
19	Middle East		493.14	583.6	667.8	762.2
20	Rest of world		923.08	1129.3	1329.1	1558.5
Annex I Total		3954.6	3922.58	4,463	4,953	5,484
% change from 1990 level			(-0.81%)	12.8%	25.2%	38.7%
% change over pvs period				13.8%	11.0%	10.7%
NAI Total			3167.2	4033.9	4932.8	5934.8
% change over pvs period				27.4%	22.3%	20.3%
World Total			7089.8	8496.5	9885.5	11418.9
% change over pvs period				19.8%	16.3%	15.5%

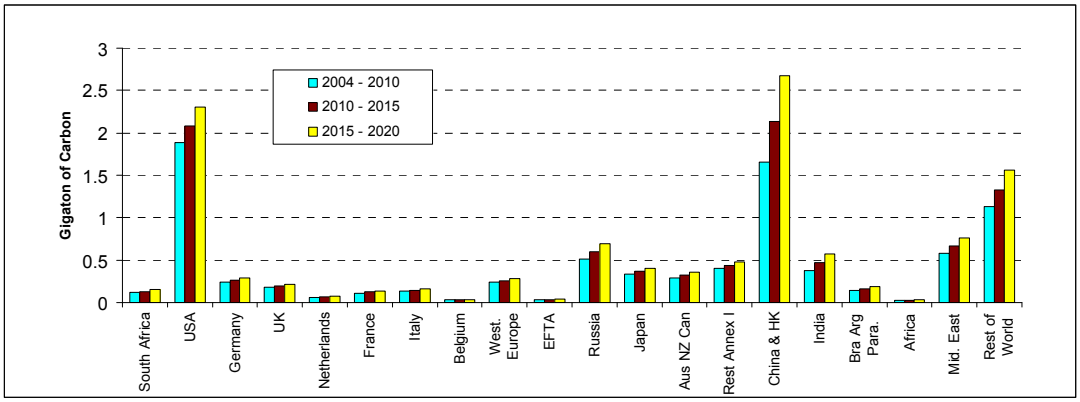


Figure 3.6: Average per annum rates of CO_2 Emission rate in the Business-as-usual (BaU) scenario – by Regions

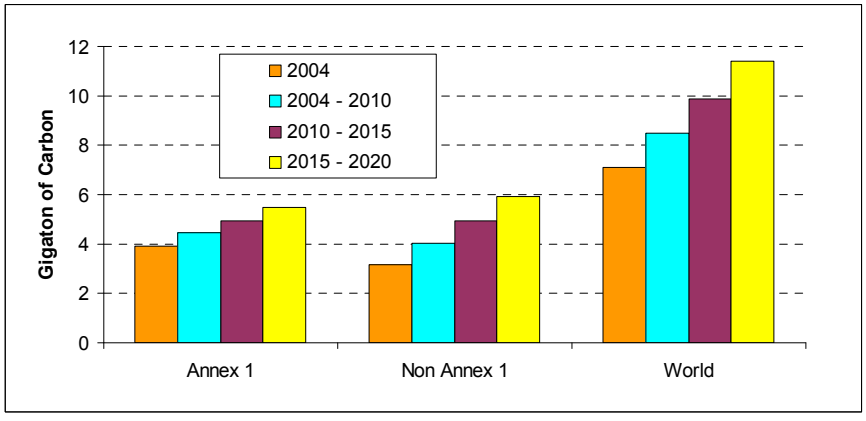


Figure 3.7: Average per annum rates of CO_2 emission in the BaU scenario – by Annex I and NAI groupings

3.3.2 Scenario 1: Annex I CO_2 reduction of 25% below 1990 levels by 2020

For this scenario, we assume that Annex I regions will respond to the challenge of climate change by agreeing to cut back on their CO_2 emissions levels to reach a level of 25% below the 1990 level emissions (of 3954.6 million tons of carbon (MtC))[23] by 2020. To reach this level, we assume for simplicity that a constant rate of emissions reduction of 8.9% over each of the three periods 2004-2010, 2010-2015, and 2015-2020 (see Table 3.5)[24]. To achieve the emissions reduction Annex I regions will have to impose a carbon tax or alternatively embark on some emissions trading scheme.[25] We assume three situations:

- Scenario 1A – No ET ('No Emissions Trade'): when there is no emissions trade between Annex I countries; each regions will try to achieve individual target reduction of CO_2 emissions without co-operation with other regions. To abstract from the issue of burden sharing we assume that each region will have to achieve the same target reduction (of -8.9% reduction over each of the three periods). The result of this simulation will then show up the differences in marginal abatement costs (MACs) of different Annex I countries.
- Scenario 1B – Annex I ET ('Annex I emissions trade'): when Annex I countries engage in emission trade with each other but not with NAI countries, the result will report a single average marginal abatement cost for all Annex I regions as a whole
- Scenario 1C – Annex I ET with NAI no-lose crediting ('Annex I emissions trade with NAI emissions reduction no-lose crediting'): to define an emissions reduction which can have 'no-lose credit', the reference or BaU emission level of a NAI region is compared to the actual emission; if the actual level is lower, then a credit is given equal to the difference, but if it is higher, then no credit is given but no penalty is imposed either[26]. This scenario is similar to what has been proposed by Schmidt *et al* (2008).

Emissions, marginal abatement costs and savings from emissions trade

Results of Scenario 1 are given in Tables 3.5–3.15 and Figures 3.8-3.10. In Tables 3.5 and Figure 3.8 the emissions levels for all regions for the three cases of Scenario 1 are shown. In the case of No ET, individual Annex I regions have to cut back their emissions by the same proportion of -8.9 % over each period.

---

23 These are total carbon dioxide emissions of Annex I Parties in 1990, for the purposes of Article 25 of the Kyoto Protocol (see: for example, http://unfccc.int/resource/docs/cop3/07a01.pdf#page=31).

24 This percentage is not per year, but for the period, derived as follows: a 8.9% reduction over 2004 results is a level of 0.91 in 2010; then 8.9% reduction over 0.91 gives a level of 0.83 in 2015, then 8.9% reduction over 0.83 gives a level of 0.756 in 2020 (all compared to 2004 level). Since 2004 is already 0.81% reduced over 1990, this gives a level of (0.756)*(1-0.0081) = 0.75 compared to 1990. Note that the period 2004-2010 is six rather than five years, therefore, -8.9% over this period is slightly less than -8.9% over the later periods 2010-2015, 2015-2020; however, for simplicity we assume the same rate for all three periods

25 From a theoretical (and modeling) viewpoint, there is no difference between a carbon tax system and an emissions trading ('cap-and-trade') system so long as the tax is consistent with the overall level of the emissions cap, and so long as the revenues from the tax (or emissions trading) are used for the same purposes. For example, if a cap and trade system is used, one must decide how to allocate the caps (by 'grandfathering' i.e. free allocation, or by auctioning). Grandfathering is equivalent to using the carbon tax revenue (if such a system is imposed) to subsidize firms for the increase in costs arising from the imposition of the climate policy. Auctioning, on the other hand, implies the government is collecting the revenue from climate policy for any purposes (including tax reform, for example). A carbon tax system implies setting the price of emissions (carbon tax) and letting polluters (consumers and firms) decide on quantities, whereas an emissions trading scheme will normally set the quantities and let the trading system work out the price. Although in theory there is no difference between the two systems, in practice, there may be important practical factors which determine if one system is preferred to the other (such as administrative cost, monitoring costs, etc).

26 Defined this way, this Scenario looks like 'half' of a full 'World emissions trading' situation when NAI regions are given 'quotas' on emissions and both a credit is given if the quota is not exceeded but a penalty will also be imposed if it is.

Table 3.5: CO_2 emissions for Scenario 1 (Gt C)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.12	0.14	0.17	0.12	0.14	0.17	0.09	0.09	0.09
2	USA	1.51	1.37	1.25	1.47	1.29	1.13	1.73	1.80	1.91
3	Germany	0.20	0.18	0.16	0.20	0.18	0.17	0.23	0.24	0.25
4	UK	0.15	0.13	0.12	0.15	0.14	0.13	0.17	0.17	0.18
5	Netherlands	0.05	0.05	0.04	0.05	0.05	0.05	0.06	0.06	0.07
6	France	0.09	0.09	0.08	0.11	0.10	0.10	0.11	0.12	0.13
7	Italy	0.11	0.10	0.09	0.12	0.12	0.11	0.13	0.14	0.15
8	Belgium	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04
9	W Europe	0.19	0.18	0.16	0.21	0.20	0.19	0.23	0.24	0.26
10	EFTA	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04
11	Russia	0.39	0.35	0.32	0.37	0.34	0.31	0.46	0.49	0.54
12	Japan	0.27	0.25	0.23	0.30	0.29	0.27	0.32	0.34	0.37
13	Aus., NZ, Canada	0.24	0.22	0.20	0.23	0.21	0.19	0.27	0.29	0.30
14	Rest Annex I	0.33	0.30	0.27	0.31	0.28	0.26	0.36	0.37	0.39
15	China & HK	1.69	2.20	2.78	1.69	2.20	2.77	1.38	1.60	1.85
16	India	0.38	0.48	0.58	0.38	0.48	0.58	0.33	0.38	0.44
17	Bra., Arg., Para.	0.15	0.17	0.19	0.15	0.17	0.19	0.14	0.15	0.17
18	Africa	0.03	0.03	0.04	0.03	0.03	0.04	0.02	0.03	0.03
19	Middle East	0.61	0.71	0.84	0.60	0.71	0.84	0.55	0.60	0.65
20	Rest of world	1.17	1.41	1.69	1.16	1.41	1.69	1.08	1.22	1.39
Annex 1 Total		3.57	3.26	2.97	3.57	3.26	2.97	4.13	4.35	4.62
% change over 1990 level		-9.6%	-17.7%	-25.0%	-9.6%	-17.7%	-25.0%	4.5%	9.9%	16.9%
% change over pvs period		-8.9%	-8.9%	-8.9%	-8.9%	-8.9%	-8.9%	5.4%	5.2%	6.4%
Non-Annex1 Total		4.14	5.15	6.28	4.14	5.15	6.28	3.58	4.05	4.62
% change over pvs period		30.7%	24.4%	22.0%	30.6%	24.4%	22.0%	13.0%	13.3%	13.9%
World total		7.71	8.41	9.25	7.71	8.40	9.25	7.71	8.40	9.25
% change over pvs period		8.8%	9.0%	10.0%	8.7%	9.0%	10.0%	8.7%	9.0%	10.0%
Leakage rate (from Annex I to NAI) (%)		-11.9%	-12.9%	-13.8%	-11.5%	-12.6%	-13.7%	138%	145%	153%

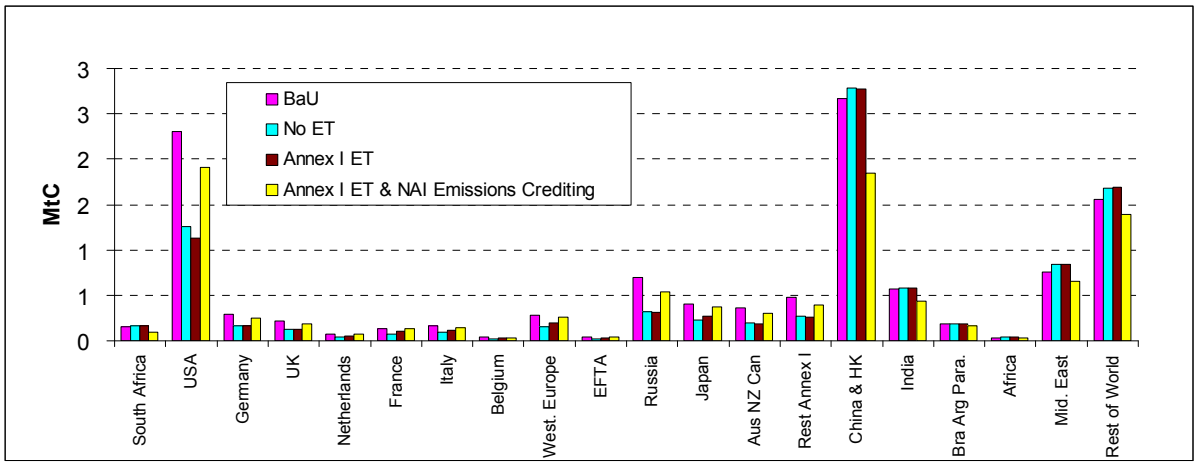


Figure 3.8: CO_2 Emission in for the BaU case Scenarios 1 (A, B, C) in the year 2020

Differences in marginal abatement costs (MACs) of Annex I regions are shown in the first three columns of Table 3.6. They can range from a low of $142/tC for 'Rest of Annex I' to a high of 428 US$/tC for France in 2010, and rising to $1928/tC in 2020. The reason for this is that France relies most heavily on nuclear energy for its energy needs and hence it is most difficult to reduce CO_2 emissions for France, while other countries such as the US and UK, still relying on coal and hence it is much easier to cut back on emissions. Because of these differences in MACs, when Annex I regions are allowed to trade in emissions, countries such as USA, UK, Russia, Australia, New Zealand, Canada, and Rest of Annex I region, will cut back on their emissions, to sell the credits to those that cannot do so as well, such as France, Italy and Japan.

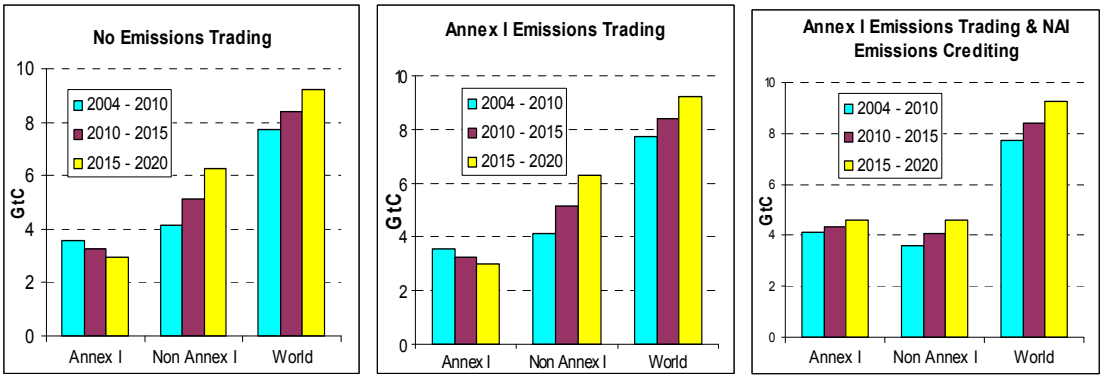


Figure 3.9: CO_2 Emission in for Scenarios 1, cases A, B, C

Table 3.6: MAC or CO_2 Emission permit price (2004 $/tC) for Scenario 1

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0	0	0	0	0	0	57	104	143
2	USA	161	375	670	183	448	834	57	104	143
3	Germany	204	501	931	183	448	834	57	104	143
4	UK	174	465	917	183	448	834	57	104	143
5	Netherlands	286	681	1232	183	448	834	57	104	143
6	France	428	1054	1928	183	448	834	57	104	143
7	Italy	332	836	1594	183	448	834	57	104	143
8	Belgium	352	874	1633	183	448	834	57	104	143
9	W Europe	315	796	1508	183	448	834	57	104	143
10	EFTA	337	779	1405	183	448	834	57	104	143
11	Russia	162	403	771	183	448	834	57	104	143
12	Japan	337	857	1640	183	448	834	57	104	143
13	Aus., NZ, Canada	170	416	765	183	448	834	57	104	143
14	Rest Annex I	142	365	750	183	448	834	57	104	143
15	China & HK	0	0	0	0	0	0	57	104	143
16	India	0	0	0	0	0	0	57	104	143
17	Bra., Arg., Para.	0	0	0	0	0	0	57	104	143
18	Africa	0	0	0	0	0	0	57	104	143
19	Middle East	0	0	0	0	0	0	57	104	143
20	Rest of world	0	0	0	0	0	0	57	104	143

The benefits of emissions trade are shown in Table 3.7. Countries which sell emissions cutback credits (cutbacks which are beyond their quotas) will gain by the revenue from sale. Countries which have to buy these credits will also save in abatement costs. Total savings for Annex I regions as a whole amount to some $4.5 billion per annum in 2010, rising to 7.4 $US billion in 2020. When Annex I regions are allowed to buy emissions reduction credits not only from each other, but also from NAI countries (Scenario 1C), the benefits are even greater. 9.6 US$ billion per annum in 2010 but slowing down to just $7.1 billion in 2020.[27] This is explained by the differences in MACs between NAI and Annex I regions which are greater than the differences among Annex I regions, hence the potential gains from emissions trade are also greater.

Table 3.7: Values of emissions trade (2004 $ million) (annual average) for Scenario 1

		Annex 1 ET			*Annex I ET with NAI no-lose crediting*		
No.	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.0	0.0	0.0	284.8	120.7	64.4
2	USA	1 256	2 387	3 487	2 088	2 151	2 060
3	Germany	101	107	82	290	290	271
4	UK	44	119	197	187	200	192
5	Netherlands	115	106	79	88	85	78
6	France	362	436	456	183	177	160
7	Italy	292	358	404	192	188	172
8	Belgium	81	98	106	48	46	42
9	W Europe	499	609	656	340	332	303
10	EFTA	78	68	57	49	47	43
11	Russia	367	181	5	669	728	734
12	Japan	720	889	1012	484	470	428
13	Aus., NZ, Canada	102	89	199	331	349	333
14	Rest Annex I	479	133	642	355	398	388
15	China & HK	0	0	0	2 621	1 733	1 123
16	India	0	0	0	469	286	181
17	Bra., Arg., Para.	0	0	0	74	53	37
18	Africa	0	0	0	11	9	6
19	Middle East	0	0	0	359	276	197
20	Rest of world	0	0	0	510	415	304
	Total	4 495	5 580	7 382	9 633	8 354	7116

Leakage

One potential negative aspect of the case of Annex I ET scenario but without participation from NAI countries even in the form of no-lose crediting is a phenomenon of so-called (emissions) 'leakage'[28]. This is defined as the increase in NAI emissions divided by the reduction in emissions of Annex I regions and expressed as a percentage. Leakage occurs when emissions-intensive activities in Annex I regions are to some extent shifted towards NAI regions, hence the increase in emissions in NAI regions. In terms of reducing emissions world-wide, there is a smaller gain – emissions have 'leaked' from one set of countries to others. From Table 3.5, it is seen that the leakage rates in the

[27] Total cumulative savings for Scenario 1C are still greater than those of Scenario 1B, even though the annual savings may be smaller in 2020 due to the fact that most potential savings have already been pushed forwards to earlier years in the case of Scenario 1C.

[28] Leakage is difficult to measure because in reality this depends on a number of factors many factors and some of which may counteract each other. The empirical estimates of leakages using simulation models also tend to vary widely because it depends on the assumptions made about trade responses (Second Assessment Report, section 11.7.2, IPCC 1996). Nevertheless, it is a phenomenon worth considering at least for the purpose of considering the potential gains from a co-operative approach to climate policy.

case of No ET and Annex I ET are similar, around 12% in 2010 rising to 14% in 2020. One further advantage of the scenario (1C) in which when NAI regions are encouraged to participate in emissions cutback by allowing them to sell their voluntary cutback credits to Annex I regions is the fact that leakage rate will not only be stopped, but can become 'positive' in the sense that there is now a cutback in emissions in NAI regions as well as in Annex I regions. The ratio of emissions reduction in NAI as compared to Annex I emissions reduction is about 138% in 2010 increasing to 153% in 2020 (last row of last three columns in Table 3.5). Because NAI emissions reductions are to compensate (exactly) for the reduced emissions cutbacks in Annex I regions the total *world* emissions therefore remain the same in both two situations (Scenario 1B and 1C) – see Table 3.5.

Trade impacts, globally and on South Africa

South Africa can potentially gain not only from emissions trade (see Scenario 1C result for South Africa in row 1 of Table 3.7), but also from trade in goods and services associated with this scenario. However, the gains from the traditional trade of goods and services can also be offset by potential losses. This depends on South Africa's sectoral impacts of Annex I response measures to climate change and the impacts of different emissions trading arrangements.

Table 3.8 shows the 'relative'[29] change in terms of trade (% change in price of Export – % change in price of import) as a result of the response measures. Terms of trade is an important factor to consider because it portrays the price advantage/disadvantage (if positive/negative) facing an exporter when the exporter is a 'price taker' i.e. a small player in the international market. This price advantage can be used to offset any changes in the volumes of exports relative to imports, or in the adverse movement of exchange rate.

Table 3.8: Change in terms of trade – Scenario 1 relative to BaU (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.24	0.48	0.62	0.21	0.43	0.54	0.03	0.08	0.07
2	USA	0.01	-0.07	-0.13	-0.08	-0.25	-0.41	0.07	0.07	0.06
3	Germany	0.16	0.19	0.26	0.15	0.18	0.27	0.11	0.10	0.09
4	UK	-0.03	-0.06	-0.07	-0.05	-0.07	-0.04	0.00	0.02	0.03
5	Netherlands	0.05	0.00	-0.09	0.08	0.09	0.07	0.07	0.08	0.07
6	France	0.12	0.08	0.07	0.20	0.23	0.30	0.13	0.13	0.11
7	Italy	0.14	0.12	0.12	0.18	0.21	0.30	0.13	0.12	0.10
8	Belgium	0.07	0.05	0.04	0.08	0.08	0.09	0.05	0.04	0.04
9	W Europe	0.06	0.01	-0.02	0.09	0.10	0.13	0.08	0.07	0.06
10	EFTA	-0.29	-0.19	0.00	-0.27	-0.18	-0.01	-0.15	-0.11	-0.07
11	Russia	-0.99	-1.13	-1.19	-1.00	-1.21	-1.29	-0.54	-0.46	-0.34
12	Japan	0.16	-0.06	-0.26	0.34	0.33	0.44	0.31	0.29	0.24
13	Aus., NZ, Canada	-0.13	-0.12	-0.11	-0.15	-0.14	-0.14	-0.08	-0.03	-0.01
14	Rest Annex I	0.03	-0.16	-0.74	-0.05	-0.32	-1.00	0.03	0.02	0.02
15	China & HK	0.14	0.18	0.21	0.13	0.15	0.17	-0.05	-0.08	-0.09
16	India	0.59	0.69	0.79	0.55	0.64	0.74	0.16	0.07	0.02
17	Bra., Arg., Para.	0.31	0.51	0.77	0.28	0.45	0.70	0.06	0.05	0.04
18	Africa	-0.97	-0.78	-0.39	-0.95	-0.81	-0.43	-0.65	-0.55	-0.39
19	Middle East	-0.71	-0.52	-0.17	-0.70	-0.54	-0.21	-0.51	-0.45	-0.32
20	Rest of world	0.02	0.11	0.22	0.01	0.09	0.20	-0.05	-0.04	-0.03

[29] By 'relative' is meant as compared to BaU scenario, i.e. after subtracting the percentage change in the terms of trade of the BaU scenario

From Table 3.8, it can be seen that South Africa clearly enjoys an improvement in terms of trade as a result of the response measures by Annex I countries. The reason is that while the world export price of coal will decrease (relative to the BaU Scenario) due to a decline demand following the imposition of climate policy, world export prices of energy-intensive industry outputs (such as chemicals rubber and plastics, iron and steel, non ferrous metals, minerals, and other manufactures) will tend to increase partly because of the higher energy input costs (see Table 3.9). Therefore, for those regions which rely mainly on the export of fossil fuels (such as Russia, Africa, Middle East), the terms of trade will decline, while those regions which export mainly energy-intensive goods such as metals, minerals, chemicals, and manufactures will experience improvements in terms of trade (USA, Germany, France, Italy, Brazil Argentina, Paraguay, China, India). South Africa's exports of coal will mean some negative impact on its terms of trade but this is not enough to offset the positive impacts due to the export of energy-intensive goods, hence South Africa can also expect an improvement in its terms of trade (Table 3.9).

Table 3.9: Change in price index of global merchandise exports from South Africa – Scenario 1 relative *to* BaU (average % per annum)

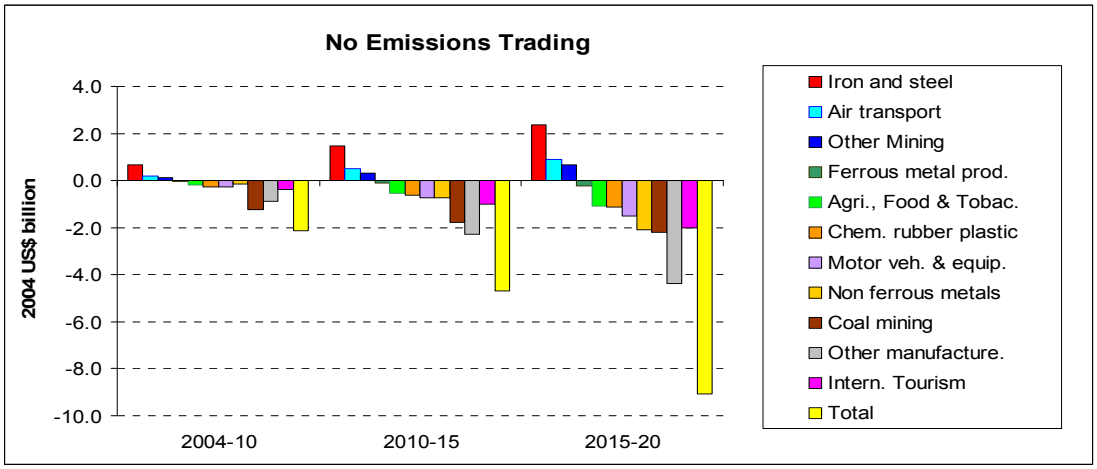
		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Sector*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	Coal mining	-1.58	0.37	1.05	-1.51	0.30	0.88	-2.37	-0.65	-0.16
2	Oil extraction	-0.83	-0.39	0.31	-0.84	-0.47	0.18	-0.80	-0.74	-0.54
3	Gas extr., manufac.	-0.25	0.77	1.13	-0.27	0.68	0.98	-1.43	-0.55	-0.26
4	Petrol. & coal prod.	-0.89	-0.37	0.22	-0.88	-0.45	0.09	-0.54	-0.30	-0.15
5	Electricity	0.14	0.96	1.35	0.11	0.86	1.19	6.37	4.12	2.67
6	Agri., food tobac.	0.63	0.99	1.28	0.57	0.89	1.14	0.04	0.03	0.04
7	Other mining	0.38	0.79	1.07	0.33	0.69	0.92	0.97	0.84	0.65
8	Paper & publishing	0.64	1.00	1.28	0.58	0.90	1.14	0.12	0.10	0.09
9	Chem. rubber plas.	0.62	0.99	1.27	0.56	0.89	1.13	0.29	0.25	0.21
10	Non metal minerals	0.63	1.04	1.34	0.57	0.94	1.19	0.63	0.53	0.41
11	Iron & steel	0.59	1.01	1.30	0.53	0.90	1.16	0.66	0.55	0.43
12	Non ferrous metals	0.75	1.14	1.42	0.68	1.03	1.27	0.26	0.20	0.16
13	Ferrous metal prod.	0.64	1.02	1.30	0.58	0.92	1.16	0.32	0.27	0.21
14	Motor veh. & equip.	0.58	0.88	1.10	0.54	0.82	1.01	0.13	0.12	0.10
15	Other manufacture.	0.64	1.00	1.27	0.58	0.90	1.14	0.09	0.08	0.07
16	Air transport	0.23	0.63	0.99	0.19	0.55	0.87	0.27	0.33	0.30
17	Trade & oth. trans.	0.63	1.01	1.32	0.56	0.91	1.17	0.02	0.02	0.04
18	Rec. cultural sport	0.66	1.02	1.31	0.59	0.92	1.17	0.12	0.08	0.07
19	Oth. market srvces	0.76	1.13	1.42	0.70	1.02	1.27	-0.12	-0.12	-0.08
20	Govt services	0.67	1.03	1.32	0.61	0.93	1.18	0.06	0.01	0.01

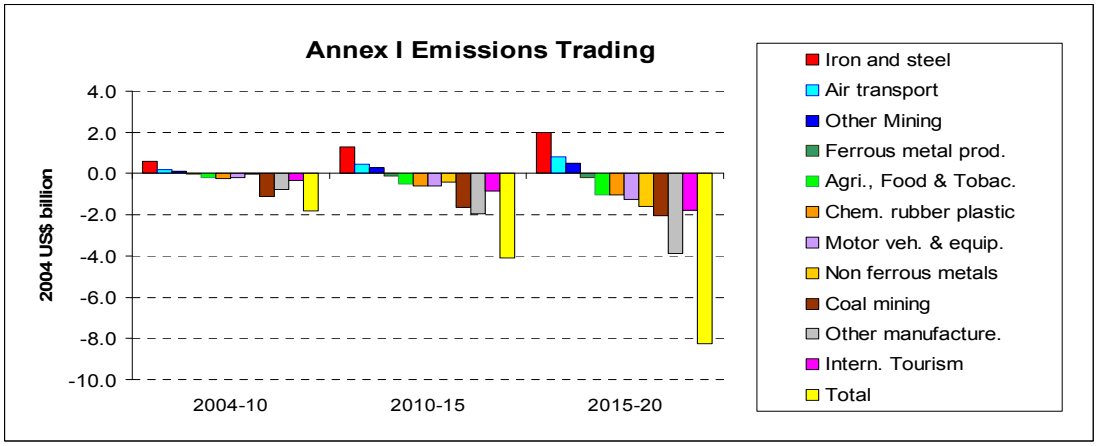
The changes in terms of trade caused by the imposition of climate response measures may be considered as an important indication of the close interrelationship between climate and trade policies. One of the concerns in international climate policy is the issue of free riding and carbon leakage through trade. However, to combat this phenomenon trade measures (such as border tax adjustments based on energy intensity or non-tariff measures such as labelling) may come into conflict with other the international measures which seek to promote free trade. Therefore, the issue of close relationship between trade and environment therefore is an important issue to be considered. However, this can go beyond the scope of this study, therefore, in this study, we limit ourselves mainly to the study of the impacts of climate response measures on South Africa based on the assumption that other (exogenously defined) measures such as border tax adjustments, non-tariff and other technical regulations) are not in place. We leave the study of these additional measures and their impacts for future studies.

Despite the improvements in terms of trade (positive price effects) the quantity effects are however negative for most sectors in South Africa as can be seen from Tables 3.10 – 3.11. In Table 3.10, the quantities of exports for most sectors except electricity, iron and steel, air transport are seen to be negative (these trends are reflected graphically in Figure 3.10).

Table 3.10: Impacts on volumes of exports from South Africa – Scenario 1 relative *to* BaU (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Sector*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	Coal mining	-5.4	-4.1	-3.1	-4.9	-3.6	-2.9	-0.3	-1.3	-1.1
2	Oil extraction	-4.3	-5.3	-5.8	-4.4	-5.5	-5.9	-1.4	-1.0	-0.7
3	Gas extr., manufac.	-9.3	-20.2	-19.3	-9.7	-20.2	-19.3	207.6	17.9	4.2
4	Petrol. & coal prod.	1.6	1.3	1.3	1.2	1.0	1.1	-0.4	-0.9	-0.8
5	Electricity	18.6	13.2	9.2	17.0	12.6	9.1	-15.0	-11.7	-7.9
6	Agri., food tobac.	-1.2	-1.9	-2.5	-1.1	-1.8	-2.4	0.5	0.4	0.3
7	Other mining	-0.1	-0.3	-0.4	-0.1	-0.3	-0.5	-1.5	-1.3	-1.0
8	Paper & publishing	-1.2	-2.1	-3.1	-1.2	-2.0	-3.0	0.5	0.5	0.4
9	Chem. Rubber plas.	-1.5	-2.2	-2.7	-1.4	-2.0	-2.5	-0.4	-0.1	0.0
10	Non metal minerals	-0.4	-0.9	-1.4	-0.6	-1.0	-1.4	-1.3	-0.8	-0.5
11	Iron and steel	1.2	0.7	-0.1	1.0	0.6	-0.2	-1.3	-0.7	-0.4
12	Non ferrous metals	-1.1	-2.2	-3.4	-0.8	-1.8	-3.0	1.1	1.5	1.2
13	Ferrous metal prod.	-1.2	-2.1	-2.8	-1.1	-1.9	-2.6	-0.6	-0.3	-0.2
14	Motor veh. & equip.	-1.5	-2.4	-3.3	-1.3	-2.1	-2.8	0.4	0.5	0.3
15	Other manufacture.	-2.2	-3.5	-4.7	-1.9	-3.1	-4.2	0.6	0.5	0.2
16	Air transport	2.9	3.0	2.3	2.6	2.8	2.4	0.2	0.0	-0.1
17	Trade & oth. Trans.	-1.2	-1.9	-2.7	-1.1	-1.8	-2.4	0.5	0.4	0.2
18	Rec. Cultural sport	-1.7	-2.8	-3.8	-1.5	-2.4	-3.3	0.1	0.2	0.2
19	Oth. Market srvces	-2.5	-3.7	-4.7	-2.2	-3.2	-4.3	1.1	1.0	0.7
20	Govt services	-1.7	-2.7	-3.5	-1.6	-2.6	-3.4	0.3	0.5	0.3





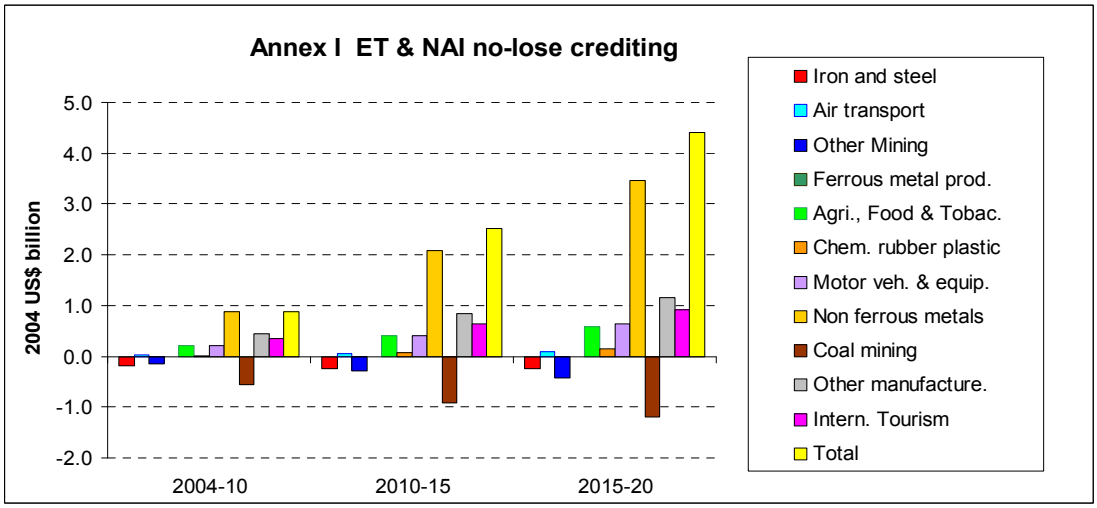


Figure 3.10: Scenario 1 – Specific export losses or gains in South African export sectors – Scenario 1 relative to BaU (total for each period in 2004 $ billion)

In Table 3.11, the picture for imports is almost the reverse, with most sectors increasing their imports except electricity, other mining, iron and steel, non ferrous metals and air transport. As a result the net impacts on the *value* of the trade balance for most sectors are negative except for a few like electricity, other mining, iron and steel, and air transport (Table 3.12). The total impact on South African trade balance is therefore also overwhelmingly negative for the case of 'no ET' and – slightly less, but still negative – for 'Annex ET'.

Table 3.11: Impacts on volumes of imports into South Africa – Scenario 1 relative *to* BaU (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Sector*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	Coal mining	0.29	1.80	2.20	0.24	1.60	1.98	-7.37	-3.60	-1.95
2	Oil extraction	0.83	0.65	0.46	0.73	0.60	0.44	-0.02	-0.32	-0.35
3	Gas extr., manufac.	5.74	17.72	17.13	6.10	16.90	16.53	-8.60	-2.45	-0.89
4	Petrol. & coal prod.	0.14	0.36	0.29	0.14	0.33	0.23	-0.16	-0.17	-0.20
5	Electricity	-4.73	-2.55	-0.94	-4.50	-2.43	-0.97	13.06	7.08	4.22
6	Agri., Food Tobac.	0.50	0.75	0.95	0.49	0.72	0.91	-0.05	-0.12	-0.08
7	Other Mining	-0.17	-0.48	-0.79	-0.14	-0.42	-0.72	0.09	0.18	0.16
8	Paper & Publishing	0.74	1.10	1.45	0.68	1.00	1.33	-0.06	-0.13	-0.09
9	Chem. rubber plas.	0.48	0.64	0.75	0.46	0.61	0.69	0.18	0.08	0.04
10	Non metal minerals	0.26	0.67	1.12	0.30	0.65	1.01	0.58	0.34	0.23
11	Iron and steel	-0.17	-0.09	-0.01	-0.06	0.00	0.04	0.52	0.38	0.25
12	Non ferrous metals	-0.62	-1.18	-1.77	-0.48	-0.99	-1.57	0.41	0.65	0.56
13	Ferrous metal prod.	0.93	1.49	2.01	0.77	1.23	1.69	-0.04	-0.05	-0.02
14	Motor veh. & equip.	1.06	1.59	2.15	0.89	1.33	1.86	-0.37	-0.30	-0.20
15	Other manufacture.	1.85	2.73	3.61	1.60	2.38	3.27	-0.65	-0.50	-0.29
16	Air transport	-1.00	-1.10	-0.93	-0.89	-1.02	-0.89	-0.17	-0.11	-0.06
17	Trade & Oth. Trans.	0.51	0.94	1.39	0.46	0.84	1.26	-0.26	-0.21	-0.11
18	Rec. cultural sport	0.84	1.46	2.10	0.73	1.28	1.90	-0.05	-0.15	-0.10
19	Oth. market srvces	1.47	2.27	3.17	1.27	1.99	2.88	-0.50	-0.46	-0.32
20	Govt services	1.09	1.78	2.40	1.07	1.80	2.51	0.07	-0.16	-0.13

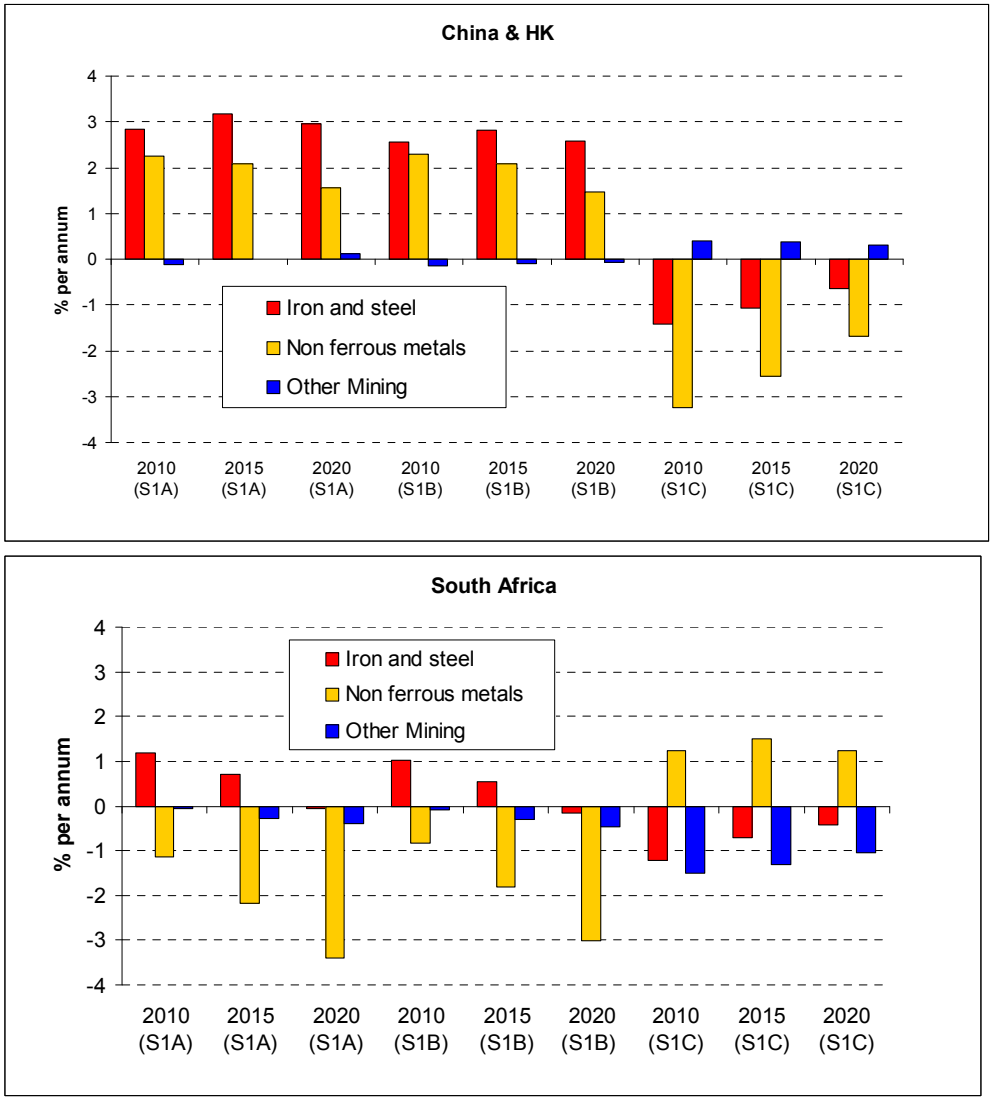
Table 3.12: Contribution to trade balance in South Africa from various sectors – Scenario 1 relative *to* BaU (average per annum in 2004 $ Million)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Sector*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	Coal mining	-203	-113	-85	-189	-103	-83	-87	-69	-57
2	Oil extraction	33	22	-13	36	31	0	61	85	86
3	Gas extr., manufac.	0	0	-1	0	0	-1	1	1	1
4	Petrol. & coal prod.	9	15	30	4	8	21	-12	-18	-18
5	Electricity	66	109	160	61	100	146	-113	-119	-122
6	Agri., Food Tobac.	-70	-135	-213	-65	-126	-199	29	38	33
7	Other Mining	18	40	66	14	31	47	-26	-32	-35
8	Paper & Publishing	-21	-45	-80	-20	-42	-76	6	11	11
9	Chem. rubber plas.	-103	-194	-295	-96	-179	-268	-33	-22	-19
10	Non metal minerals	-5	-14	-28	-6	-14	-27	-11	-10	-10
11	Iron and steel	109	153	159	95	129	127	-42	-23	-14
12	Non ferrous metals	-29	-113	-257	-9	-82	-221	122	212	243

		No ET			Annex 1 ET			Annex I ET with NAI no-lose crediting		
No.	*Sector*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
13	Ferrous metal prod.	-21	-46	-78	-18	-40	-68	-6	-4	-4
14	Motor veh. & equip.	-190	-384	-638	-166	-336	-563	40	51	46
15	Other manufacture.	-543	-1098	-1859	-473	-958	-1648	141	153	115
16	Air transport	34	57	69	31	52	67	3	2	1
17	Trade & Oth. Trans.	-40	-85	-147	-36	-77	-132	17	19	15
18	Rec. cultural sport	-18	-38	-63	-15	-33	-56	3	5	5
19	Oth. market srvces	-54	-102	-163	-47	-90	-146	22	27	26
20	Govt services	-20	-41	-68	-19	-39	-66	2	6	6
	Total	-1048	-2016	-3503	-919	-1770	-3144	117	313	309

Only in the case of 'Annex I trading and NAI no-lose crediting' that some positive change in the trade balance can be observed. The reason is that only with 'Annex I trading and NAI no-lose crediting' (Scenario 1C) that some turn around in the trade balance can be observed. This can be explained by the fact that only in Scenario 1C countries Annex I countries can enjoy some moderate increase in CO_2 emissions by relying on NAI countries to do some of the work of reducing emissions for them (see Figures 3.8 and 3.9). This implies that the world as a whole is more 'efficient' in reducing CO_2 emissions if there is international co-operation as compared to the cases of less (Annex I ET) or no co-operation (no ET). The increase in efficiency is also the result of lower mitigation costs in NAI countries, as represented in the modelling in abatement cost curves and lower costs of labour and other factors of production. The positive impacts on export of energy-intensive goods from South Africa can be partly attributed to the fact that with 'Annex I trading and NAI no-lose crediting', the switch of energy-intensive goods production activities from Annex I countries to NAI countries has decreased for a major NAI country such as China (see Figure 3.11) and therefore, allowing more room for export from South Africa.

Although the switch in energy and emission-intensive production activities from Annex I to NAI countries is often seen as a negative phenomenon – the leakage effect discussed earlier; in the case of 'Annex I trading and NAI no-lose crediting' (i.e. with active participation from NAI regions even though without any binding constraints) the leakage phenomenon is not only stopped but turned around from a negative phenomenon to a positive one. Now, NAI regions can make a contribution towards climate change abatement. The benefit to a NAI country such as South Africa in this case is twofold: (i) an opportunity to earn revenue from emissions reduction efforts (see Table 3.7, where the value of emissions trade for South Africa is some $285 million in 2010, declining to $64 million in 2020); and (ii) increased export activities arising from the fact that with increased emissions and hence increased economic activities in Annex I regions, their demand for South African export goods will also increase through the income effect.



(S1): Scenario 1; (A) No ET; (B): Annex I ET; (C): Annex I ET with NAI no-lose crediting.

Figure 3.11: Change in export for energy intensive sectors – relative to BaU (average % per annum)

Specific losses or gains in some important South African export sectors

Table 3.13A shows the specific losses or gains[30] (relative to BaU scenario) by sectors for the South African economy including the special sector 'International tourism' which is defined here in terms of the expenditures of international tourists in the various sectors of the South African economy (see above).[31] Figure 3.10 highlights the gains or losses for the export-oriented sectors. It can be seen that in the case of 'No ET' and 'Annex I ET', all sectors except 'Iron and steel', 'Air transport', and 'Other mining' suffer losses, and these losses continue until the end of the period 2015-2020. Only in the case of 'Annex I trading and NAI no-lose crediting' (Scenario 1C) that the picture turns around. We now see the reverse situation where all sectors which previously suffered negative impacts under 'No ET' and 'Annex I ET' will now enjoy positive impacts. Conversely, 'Other mining' and 'Iron and steel' will experience a switch from positive impacts to negative impacts.

30 Gains and losses are defined in relation to the BaU Scenario, i.e., they measure the impacts due to the imposition of climate policies or response measures to climate change in Annex I regions.

31 Note that since 'International Tourism' is defined in terms of the expenditures in various sectors, including international transport (ATP) (making up 74.2% of the export value of this sector), therefore, we cannot add the gains/losses of the international tourism sector to the rest of the economy to get the 'total' (in Table 3.13) as this will involve double counting.

Coal is the only sector which suffers from negative impacts under all three situations, and Air transport is the only sector which enjoys positive impact under all three situations. Note that 'International tourism', even though including Air transport as one important component also includes other service sectors as its components and these sectors suffer from negative impacts under 'No ET' and 'Annex I ET', hence as a whole 'International tourism' (as we defined it above) also suffers from (net) negative impacts under these situations, and only turns around to a positive impact when there is 'Annex I trading with NAI no-lose crediting' (Scenario 1C).[32]

Table 3.13A: Specific export losses or gains in South African sectors – Scenario 1 relative *to* BaU (total for each period in 2004 $ billion)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Sector*	*2004-2010*	*2010-2015*	*2015-2020*	*2004-2010*	*2010-2015*	*2015-2020*	*2004-2010*	*2010-2015*	*2015-2020*
1	Coal mining	-1.23	-1.79	-2.20	-1.14	-1.65	-2.05	-0.55	-0.91	-1.20
2	Oil extraction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Gas extr., manufac.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
4	Petrol. & coal prod.	0.04	0.11	0.27	0.01	0.04	0.16	-0.09	-0.19	-0.30
5	Electricity	0.31	0.83	1.63	0.28	0.75	1.48	-0.21	-0.30	-0.36
6	Agri., Food Tobac.	-0.21	-0.54	-1.07	-0.20	-0.51	-1.03	0.21	0.41	0.59
7	Other Mining	0.12	0.33	0.67	0.10	0.26	0.50	-0.14	-0.28	-0.43
8	Paper & Publishing	-0.04	-0.12	-0.28	-0.04	-0.12	-0.29	0.05	0.11	0.18
9	Chem. rubber plas.	-0.25	-0.61	-1.12	-0.24	-0.58	-1.05	0.01	0.07	0.15
10	Non metal minerals	0.01	0.02	0.03	0.00	0.01	0.00	-0.02	-0.02	-0.03
11	Iron and steel	0.68	1.49	2.37	0.60	1.29	2.00	-0.18	-0.24	-0.25
12	Non ferrous metals	-0.16	-0.73	-2.08	-0.03	-0.44	-1.59	0.88	2.08	3.47
13	Ferrous metal prod.	-0.04	-0.11	-0.23	-0.03	-0.09	-0.20	-0.01	-0.01	-0.01
14	Motor veh. & equip.	-0.27	-0.74	-1.49	-0.22	-0.62	-1.25	0.20	0.41	0.63
15	Other manufacture.	-0.88	-2.29	-4.39	-0.75	-1.97	-3.88	0.45	0.85	1.16
16	Air transport	0.20	0.50	0.90	0.18	0.45	0.83	0.03	0.06	0.08
17	Trade & Oth. Trans.	-0.09	-0.24	-0.49	-0.08	-0.22	-0.45	0.09	0.16	0.22
18	Rec. cultural sport	-0.08	-0.21	-0.42	-0.06	-0.18	-0.37	0.03	0.05	0.08
19	Oth. market srvces	-0.18	-0.45	-0.85	-0.16	-0.39	-0.76	0.11	0.21	0.32
20	Govt services	-0.06	-0.16	-0.31	-0.06	-0.15	-0.30	0.03	0.06	0.09
International tourism		-0.38	-1.01	-2.01	-0.33	-0.87	-1.78	0.34	0.65	0.93
Total		-2.11	-4.71	-9.07	-1.84	-4.11	-8.24	0.88	2.52	4.41

First, the positive impacts for 'Air transport' in South Africa can be explained partly by the fact that 26.6% of Air transport services are used as inputs into 'Other market services', and this sector performs well in Scenarios 1A and 1B (but not Scenario 1C) – see Table 3.14B. This can be called the 'income effect'. The other effect is 'substitution': with climate response measures imposed, world demand for fossil fuels (including petroleum products) decreases substantially and this depresses their supply prices (see Table 3.15). Since petroleum product is a major input into Air transport, this helps reduce the Air transport costs in South Africa and hence having a positive impact (substitution effect) on the level of demand and output of Air transport in South Africa (see second last row of Table 3.15). This is despite a world wide trend in reduced demand/supply (income effect) (see third last row of Table 3.15). Only in the last two periods of Scenario 1C that

[32] Note that no specific link between global climate change (such as considered by Hamilton *et al,* 2005) and its mitigation responses is considered here. Thus, impacts on the tourism industry as considered in this section are solely derived from the *economic* impacts of response measures and not the global climate change impacts on the number and distribution of international tourists which is further considered in the next section.

the world wide trend (income effect) overwhelms the domestic (substitution effect) and therefore, the total demand/supply of Air transport in South Africa decreases (relative to BaU Scenario). Export of Air transport from South Africa, however, remains positive (relative to BaU) – see last row of Table 3.15, despite the slowdown in total output, which implies most of decline in demand are from domestic travellers rather than foreign travellers.

Next, the positive impacts of Scenario 1C for most other South African sectors besides 'Air transport' (and except 'Iron and steel', 'Other mining', and 'Coal') can be explained by the fact that with 'Annex I trading and NAI no-lose crediting', an NAI country such as China will find it profitable to reduce some of its production activities (especially in energy-intensive sectors) to decrease emissions levels and then sell these credits to Annex I countries (see Figure 3.11). This is compared to the 'No ET' and 'Annex I trading' (scenarios 1A and 1B) where such an option is not available. This will then decrease the pressure of competition for exports to Annex I countries for South Africa and hence South Africa can enjoy some positive effects. This is particularly true for sectors such as 'Other manufacturing', 'Motor vehicle, parts, and transport equipment', 'Chemical, rubber, and plastics', 'Fabricated metal products', and 'Agri., food, bev. & tobacco' where Chinese exports are predominant (see Figure 3.12). In the case of 'Iron and steel', despite the reduction in Chinese export, this reduction is not as strong (as compared to the case of 'Non-ferrous metals' (see Figure 3.11). Furthermore, South Africa may also find it attractive to reduce its own emissions in 'Iron and steel' production to sell emissions reduction credit to Annex I countries. Hence the net effect is negative for 'Iron and steel' export from South Africa. The case of 'Other mining' is partly explained by the fact that China is not reducing its export but in fact increasing it (see Figure 3. 11), However, since Chinese export in this sector is not dominant (see Figure 3.12), this negative impact on South African export of 'Other mining' is explained mainly by the fact that world demand for 'Other mining' is declining (relative to BaU), in all Scenarios but especially in Scenario 1C (-0.01% -0.78%, -1.08% for the three periods in Scenario 1B, and -0.13% -0.96%, -1.30% for the three periods in Scenario 1C).

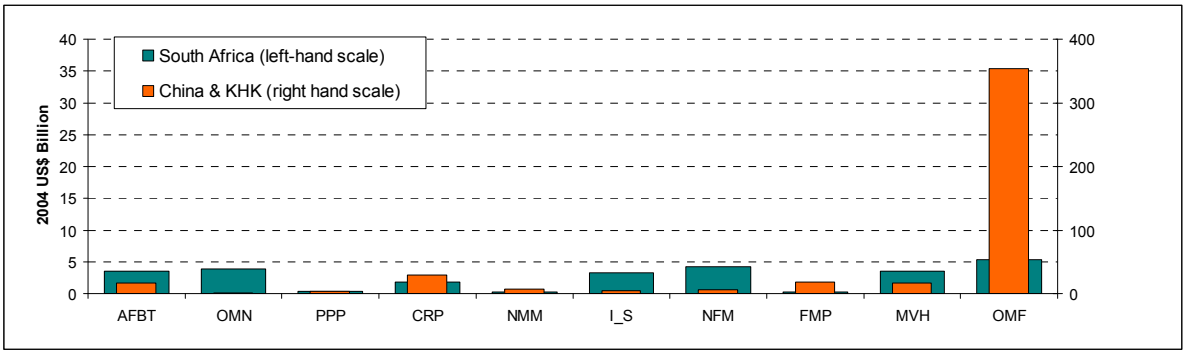


Figure 3.12: Total exports in 2004 to Annex I countries by South Africa and China by sectors ($ billion)

Climatic impacts on International tourism

Based on a study by Hamilton *et al* (2006), we estimate the change in total number of international tourists into South Africa which is shown in Table 3.13B. This change in total number of international tourists will impact on the export revenue of the sectors which are assumed to make up the 'International tourism' sector as shown in Table 3.2. The magnitudes of these impacts are also shown in Table 3.13B. Based on these impacts, we re-run the BaU Scenario but with these impacts introduced as exogenous shocks to the model[33].

The results of the 'new' BaU Scenario (i.e. the BaU Scenario 'with climate change') when compared with the 'old' BaU Scenario (BaU without climate change) gives us the (negative) value of the impacts on international tourism to South Africa due to climate change. If climate response measures

[33] The reason for introducing these shocks only to the BaU Scenario (but not to the Policy Scenarios 1 or 2 is that 'climate change' is assumed to be occurring only if no climate response measures are introduced.

(in Scenario 1 or 2) can prevent 'climate change' completely[34], then the magnitude of these (negative) impacts could be considered as the 'extra value' of climate measures to South Africa because they are the value of international tourism that would not be lost *if* climate change is completely prevented. These extra values are shown in Table 3.13C. When we add these extra values to Table 3.13A, we get the *net* gains/losses for Scenario 1. International tourism is now seen to have positive net gains rather than losses (except for period 2015-2020 for the 'No ET' Scenario – see second last row in Table 3.13C). The total net gains/losses for South Africa are also much improved if we assume climate response measures in Scenario 1 can prevent climate change from occurring.

Table 3.13B: Changes in the number of international tourists into South Africa due to climate change and their impacts on expenditures in various sectors

	Description	*2004-2010*	*2010-2015*	*2015-2020*
	Net change in International Tourists into South Africa due to climate change (*)	-6.21%	-7.45%	-8.68%
	Impacts on sectoral expenditure:			
4	Petroleum & coal products.	-0.50%	-0.60%	-0.69%
6	Agriculture, forestry, fishing, food beverages and tobacco	-0.62%	-0.75%	-0.87%
9	Chemical, rubber, plastic products	-0.01%	-0.01%	-0.02%
15	Other manufacturing	-1.46%	-1.76%	-2.05%
16	Air transport	-4.60%	-5.53%	-6.44%
17	Trade and transport (excl. air transport)	-5.29%	-6.35%	-7.40%
18	Recreational and other services	-5.29%	-6.35%	-7.40%
19	Other market services	-5.67%	-6.81%	-7.93%
* Based on Hamilton *et al* (2006).				

Table 3.13C: The value of International tourism to South Africa sectors which will *not* be lost if climate change is prevented (total for each period in 2004 $ billion)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Sector*	*2004-2010*	*2010-2015*	*2015-2020*	*2004-2010*	*2010-2015*	*2015-2020*	*2004-2010*	*2010-2015*	*2015-2020*
1	Coal mining	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01
2	Oil extraction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Gas extr., manufac.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Petrol. & coal prod.	0.01	0.02	0.04	0.01	0.02	0.04	0.01	0.02	0.04
5	Electricity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Agri., Food Tobac.	0.07	0.16	0.27	0.07	0.16	0.27	0.07	0.16	0.27
7	Other Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Paper & Publishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Chem. rubber plas.	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01
10	Non metal minerals	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Iron and steel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	Non ferrous metals	0.02	0.04	0.07	0.02	0.04	0.07	0.02	0.04	0.07
13	Ferrous metal prod.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	Motor veh. & equip.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Other manufacture.	0.19	0.46	0.82	0.19	0.46	0.82	0.19	0.46	0.82

[34] Since there is no way of ascertaining 'how much' of the 'climate change' (in Hamilton *et al* (2005) study) can be prevented by Scenario 1 or 2, we assume for simplicity that *all* of it (or at least as far as the impact on International tourism is concerned) is prevented.

		No ET			Annex 1 ET			Annex I ET with NAI no-lose crediting		
No.	*Sector*	*2004-2010*	*2010-2015*	*2015-2020*	*2004-2010*	*2010-2015*	*2015-2020*	*2004-2010*	*2010-2015*	*2015-2020*
16	Air transport	0.07	0.16	0.28	0.07	0.16	0.28	0.07	0.16	0.28
17	Trade & Oth. Trans.	0.20	0.47	0.81	0.20	0.47	0.81	0.20	0.47	0.81
18	Rec. cultural sport	0.09	0.22	0.39	0.09	0.22	0.39	0.09	0.22	0.39
19	Oth. market srvces	0.15	0.34	0.60	0.15	0.34	0.60	0.15	0.34	0.60
20	Govt services	0.00	0.01	0.02	0.00	0.01	0.02	0.00	0.01	0.02
International tourism		0.49	1.15	2.00	0.49	1.15	2.00	0.49	1.15	2.00
Total		0.80	1.90	3.32	0.80	1.90	3.32	0.80	1.90	3.32
Net gains/losses to International tourism		0.10	0.14	-0.01	0.15	0.28	0.22	0.82	1.80	2.93
Net gains/losses to all sectors		-1.31	-2.80	-5.75	-1.04	-2.21	-4.92	1.68	4.43	7.73

Domestic microeconomic impacts on South Africa

Table 3.14A looks at the domestic growth rates of sectors in the South African economy under the three Scenarios 1A, 1B, and 1C. With the (assumed) underlying GDP growth rates of 3.0%, 2.8%, and 2.8% respectively for the three periods ending from 2004 to 2020 (see Table 3.2, repeated in the first row of Table 3.14) we can see that the growth rates of sectoral outputs are also mostly around these 'underlying' figures. The services sectors such as 'Air transport', 'Recreational, cultural, and sport', 'Other market services', 'Other government services' are experiencing slightly higher growth rates than average, while export-oriented sectors such as 'Coal mining', 'Agriculture, food, beverages and tobacco', 'Other mining', 'Paper and publishing', 'Chemical, rubber and plastics', 'Non-ferrous metals', 'Other manufacturing' are experiencing slower (or even negative in the case of 'Non-ferrous metals') output growth.

The rates of growth of employment for skilled and unskilled labour are also slightly higher than GDP growth rates, while that of capital is slightly lower. This reflects two conflicting trends. On the one hand, climate policy will impact on energy usage and hence encourage a substitution away from energy towards more capital (more energy-efficient technologies). This is called the energy-capital (or energy-efficiency) substitution effect. On the other hand, energy-intensive industries will also tend to be capital-intensive; hence a substitution away from energy-intensive industries towards less energy-intensive activities will also mean a substitution towards more labour and less capital. This is called the composition effect. If the composition effect is stronger than the energy-efficiency effect (such as the case for South Africa), then labour will be growing at a faster rate than capital. If the opposite is true (such as for the case of USA) then capital will be growing at a faster rate than labour.[35]

[35] For the USA, capital is growing at about 0.5–1% higher than labour for the cases of 'No ET' and 'Annex I ET', but only 0.1- 0.2% higher for the case of 'Annex I trading and NAI emissions crediting'.

Table 3.14A: Growth rates of GDP, population, primary factors and sectoral outputs in South Africa – Scenario 1 (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Factor/sector*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
	GDP	2.99	2.83	2.77	2.99	2.83	2.77	2.99	2.83	2.77
	Population	0.73	-0.34	0.10	0.73	-0.34	0.10	0.73	-0.34	0.10
	Land	3.11	3.03	3.01	3.10	3.01	2.99	2.97	2.87	2.81
	Unskilled labour	3.03	2.89	2.83	3.03	2.89	2.83	2.97	2.87	2.81
	Skilled labour	3.05	2.92	2.88	3.04	2.91	2.87	2.96	2.86	2.81
	Capital	2.84	2.65	2.55	2.86	2.67	2.57	3.17	3.03	2.93
	Natural resources	3.18	3.04	3.02	3.16	3.03	3.00	3.05	2.89	2.82
1	Coal mining	0.78	1.41	1.80	0.96	1.57	1.82	0.22	0.64	1.14
2	Oil extraction	1.84	1.06	0.44	1.88	1.11	0.51	2.46	2.21	2.13
3	Gas extr., manufac.	3.56	2.98	2.67	3.50	2.95	2.67	2.06	2.01	2.14
4	Petrol. & coal prod.	3.72	3.32	3.11	3.63	3.26	3.09	2.88	2.36	2.31
5	Electricity	3.98	3.53	3.29	3.92	3.48	3.26	-0.60	0.48	1.20
6	Agri., Food Tobac.	2.13	1.65	1.60	2.14	1.67	1.62	2.57	2.13	2.13
7	Other Mining	2.84	2.60	2.37	2.83	2.57	2.31	1.42	1.58	1.76
8	Paper & Publishing	2.64	2.21	1.93	2.66	2.25	1.98	3.18	2.99	2.89
9	Chem. rubber plas.	2.34	1.86	1.61	2.39	1.95	1.72	2.94	2.81	2.77
10	Non metal minerals	3.06	2.83	2.71	3.01	2.80	2.72	2.71	2.68	2.69
11	Iron and steel	3.48	2.95	2.46	3.42	2.91	2.46	2.36	2.46	2.57
12	Non ferrous metals	2.24	1.01	-0.34	2.53	1.38	0.06	4.59	4.68	4.28
13	Ferrous metal prod.	3.04	2.65	2.47	3.05	2.68	2.53	2.63	2.60	2.64
14	Motor veh. & equip.	3.00	2.64	2.47	3.05	2.76	2.68	3.18	3.04	2.97
15	Other manufacture.	2.53	2.01	1.77	2.59	2.12	1.90	3.00	2.73	2.66
16	Air transport	4.15	4.10	3.76	4.01	4.02	3.77	2.90	2.64	2.57
17	Trade & Oth. Trans.	2.60	2.22	2.04	2.63	2.27	2.11	2.90	2.70	2.65
18	Rec. cultural sport	3.02	2.91	2.76	3.04	2.94	2.78	3.24	3.14	3.01
19	Oth. market srvces	3.45	3.48	3.55	3.40	3.43	3.50	3.02	2.94	2.87
20	Govt services	3.11	3.08	3.03	3.11	3.07	3.01	3.28	3.09	2.96

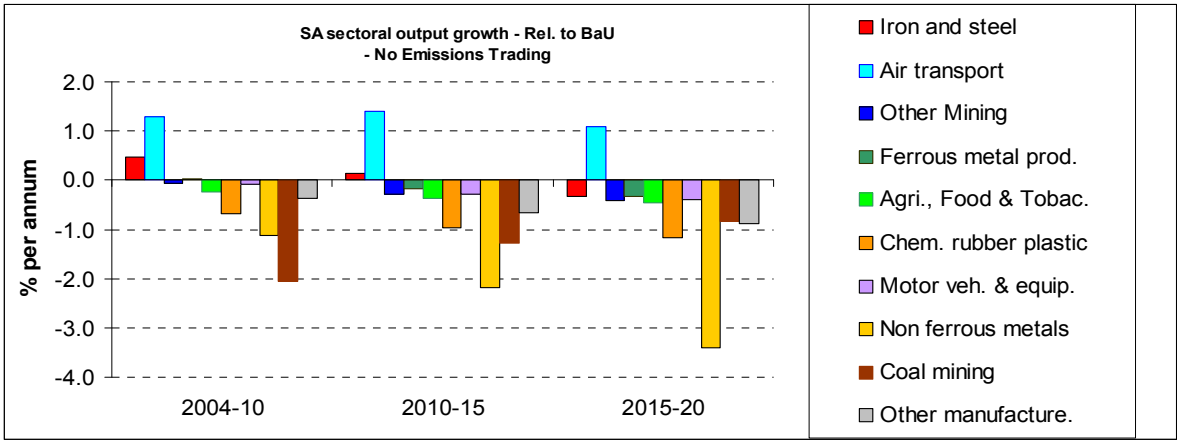
To examine the impacts of response measures only on South Africa, the average rates of growth of the BaU scenario must be subtracted from the scenario growth rates. These are referred to as relative growth rates and are shown in Table 3.14B and Figure 3.13. It can be seen that impacts of climate response measures on South African sectoral output growth are consistent with the impacts on sectoral export performance discussed earlier. Most of these impacts are negative, and only in a few cases ('Air transport', and other services sectors) that the impacts are positive. When there is 'Annex I ET with NAI no-lose crediting', however, there is a significant reversal in the impacts for 'Non ferrous metals' as compared to the cases of 'No ET' and 'Annex I ET'. This can be explained partly by the reversal in export performance of this sector as described earlier (see Figures 3.10 and 3.11).

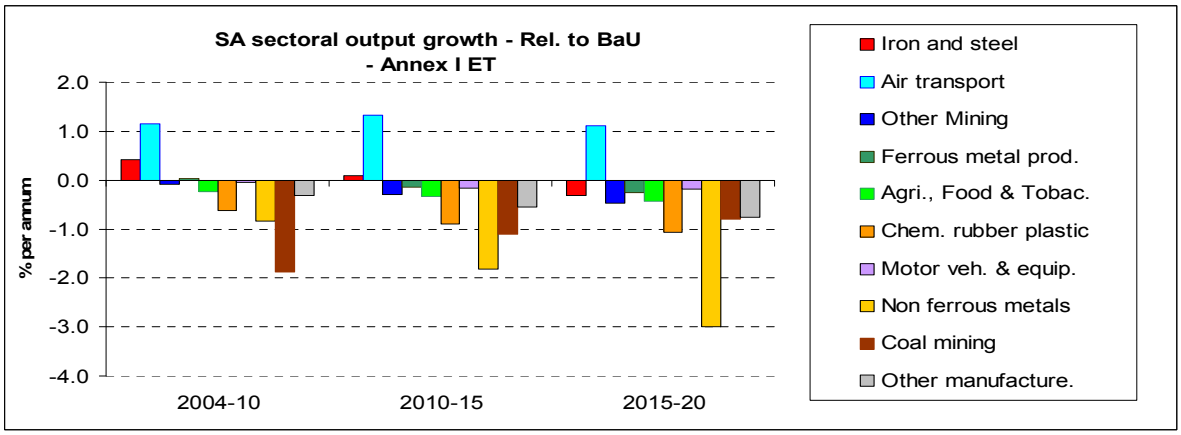
Table 3.14B: Relative growth rates of GDP, population, primary factors and sectoral outputs in South Africa – Scenario 1 *Relative to* BaU (average % per annum).

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Factor/Sector*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
	GDP	0	0	0	0	0	0	0	0	0
	Population	0	0	0	0	0	0	0	0	0
	Land	0.14	0.20	0.25	0.13	0.18	0.22	-0.01	0.04	0.04
	Unskilled labour	0.04	0.04	0.05	0.03	0.04	0.05	-0.03	0.03	0.03
	Skilled labour	0.07	0.10	0.12	0.07	0.09	0.11	-0.02	0.04	0.04
	Capital	-0.16	-0.20	-0.23	-0.14	-0.18	-0.21	0.17	0.18	0.15
	Natural resources	0.19	0.21	0.25	0.18	0.19	0.23	0.07	0.05	0.05
1	Coal mining	-2.06	-1.27	-0.82	-1.88	-1.11	-0.81	-2.62	-2.05	-1.49
2	Oil extraction	-1.01	-1.67	-2.21	-0.97	-1.62	-2.14	-0.39	-0.51	-0.52
3	Gas extr., manufac.	0.59	0.21	-0.06	0.52	0.18	-0.06	-0.92	-0.75	-0.59
4	Petrol. & coal prod.	0.80	0.63	0.44	0.71	0.58	0.42	-0.04	-0.32	-0.35
5	Electricity	0.99	0.71	0.53	0.93	0.66	0.50	-3.59	-2.33	-1.56
6	Agri., food tobac.	-0.24	-0.36	-0.46	-0.23	-0.34	-0.44	0.20	0.12	0.07
7	Other mining	-0.07	-0.28	-0.41	-0.08	-0.30	-0.47	-1.49	-1.29	-1.02
8	Paper & publishing	-0.40	-0.64	-0.87	-0.37	-0.60	-0.82	0.14	0.14	0.09
9	Chem. rubber plas.	-0.68	-0.97	-1.17	-0.63	-0.89	-1.06	-0.08	-0.02	-0.01
10	Non metal minerals	0.04	-0.04	-0.10	-0.01	-0.07	-0.10	-0.31	-0.20	-0.12
11	Iron and steel	0.47	0.13	-0.32	0.41	0.09	-0.32	-0.65	-0.35	-0.20
12	Non ferrous metals	-1.12	-2.18	-3.40	-0.83	-1.81	-3.00	1.23	1.49	1.23
13	Ferrous metal prod.	0.03	-0.17	-0.32	0.03	-0.14	-0.25	-0.38	-0.22	-0.14
14	Motor veh. & equip.	-0.09	-0.29	-0.40	-0.04	-0.17	-0.18	0.08	0.12	0.10
15	Other manufacture.	-0.38	-0.66	-0.88	-0.32	-0.55	-0.76	0.09	0.06	0.00
16	Air transport	1.29	1.41	1.10	1.15	1.32	1.12	0.04	-0.05	-0.08
17	Trade & oth. trans.	-0.29	-0.45	-0.61	-0.26	-0.40	-0.54	0.02	0.02	0.01
18	Rec. cultural sport	-0.18	-0.22	-0.26	-0.16	-0.19	-0.24	0.04	0.00	-0.01
19	Oth. market srvces	0.36	0.50	0.66	0.31	0.44	0.61	-0.07	-0.05	-0.02
20	Govt services	0.02	0.10	0.13	0.02	0.08	0.11	0.19	0.10	0.06

Table 3.15: Change in the world supply price of energy commodities and impact on Air transport – Scenario 1 relative to BaU (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Commodity*	*2004-2010*	*2010-2015*	*2015-2020*	*2004-2010*	*2010-2015*	*2015-2020*	*2004-2010*	*2010-2015*	*2015-2020*
1	Coal	-2.12	-1.31	-1.86	-2.14	-2.08	-1.92	-2.64	-2.95	-2.77
2	Crude oil	-0.80	-1.24	-2.01	-0.74	-1.77	-1.99	-0.43	-1.22	-1.34
3	Gas	-3.04	-2.95	-2.78	-3.08	-3.33	-2.86	-1.66	-2.03	-1.79
4	Petrol. & coal prod.	-0.84	-1.33	-2.13	-0.75	-1.83	-2.11	-0.43	-1.22	-1.35
5	Electricity	-2.12	-1.31	-1.86	-2.14	-2.08	-1.92	-2.64	-2.95	-2.77
World supply of Air transport		-0.16	-0.27	-1.00	-0.14	-0.83	-0.99	-0.05	-0.67	-0.80
SA supply of Air transport		1.29	1.41	1.10	1.15	1.32	1.12	0.04	-0.05	-0.08
SA export of Air transport		0.20	0.50	0.90	0.18	0.45	0.83	0.03	0.06	0.08





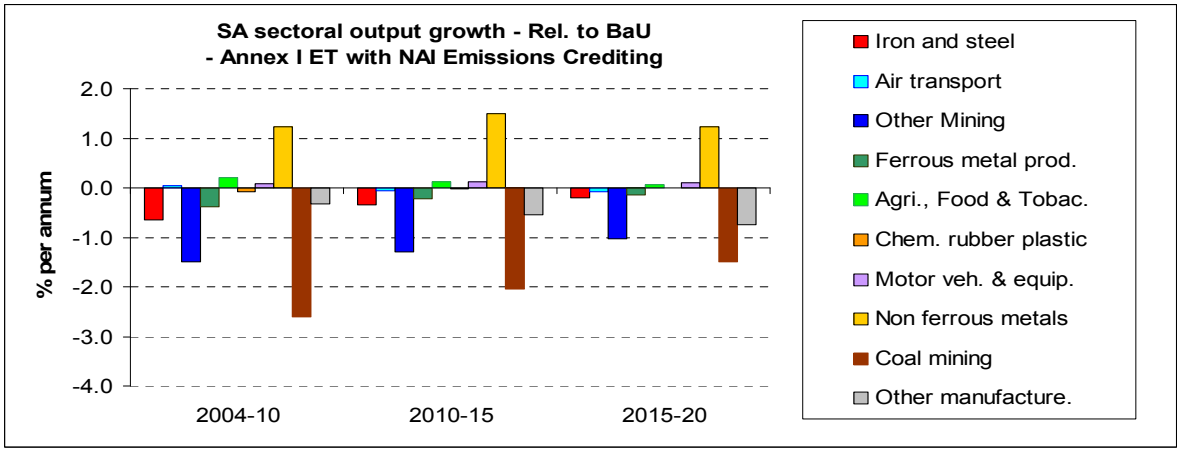


Figure 3.13: Sectoral output growth in South Africa – Scenario 1 relative to BaU (average % per annum)

Table 3.16A shows the (real)[36] *absolute* changes in supply price indices of primary factors and sectoral outputs in South Africa. Table 3.16B shows the price changes *relative* to the BaU scenario. It can be seen from these tables that that the impacts on domestic prices of primary factors (except natural resources) and of all sectoral outputs (except fossil fuels) are positive, indicating the generally higher costs which flow on from the implementation of climate policies (and in the absence of any technological progress.

[36] Since most computable general equilibrium models (including GTAP-E model) are of the Walrasian type and there are no monetary assets in the model, therefore, all prices are in 'real' terms and defined relative to a numeraire. In the case of our simulations, we have chosen to use the world average price index for primary factors as the numeraire, hence all prices are relative to this numeraire.

Table 3.16A: Change in supply price of primary factors and industry outputs in South Africa – Scenario 1 (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Factor/sector*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
	Land	-0.87	-1.13	-0.91	-0.90	-1.17	-0.97	-0.72	-1.21	-1.11
	Unskilled labour	0.50	0.87	1.15	0.44	0.78	1.01	0.01	-0.01	-0.03
	Skilled labour	0.69	1.16	1.45	0.62	1.05	1.29	0.12	0.09	0.04
	Capital	0.88	1.27	1.57	0.80	1.14	1.40	-0.62	-0.52	-0.41
	Natural resources	-7.24	-3.79	-2.57	-6.92	-3.68	-2.79	-8.92	-5.95	-4.02
1	Coal mining	-1.89	0.08	0.78	-1.82	0.01	0.61	-2.68	-0.95	-0.44
2	Oil extraction	-1.12	-0.62	0.06	-1.13	-0.70	-0.08	-1.09	-0.98	-0.80
3	Gas extr., manufac.	-0.44	0.58	0.95	-0.45	0.49	0.81	-1.62	-0.74	-0.44
4	Petrol. & coal prod.	-1.16	-0.58	-0.01	-1.15	-0.65	-0.14	-0.80	-0.51	-0.38
5	Electricity	0.01	0.85	1.23	-0.03	0.75	1.08	6.23	4.01	2.55
6	Agri., food tobac.	0.52	0.90	1.18	0.46	0.80	1.04	-0.08	-0.06	-0.06
7	Other Mining	0.26	0.72	0.99	0.21	0.63	0.84	0.83	0.78	0.57
8	Paper & publishing	0.57	0.95	1.22	0.51	0.85	1.08	0.03	0.04	0.02
9	Chem. rubber plas.	0.54	0.93	1.20	0.48	0.84	1.07	0.20	0.19	0.14
10	Non metal minerals	0.55	0.98	1.27	0.49	0.88	1.12	0.53	0.46	0.33
11	Iron and steel	0.50	0.94	1.23	0.45	0.84	1.09	0.56	0.49	0.35
12	Non ferrous metals	0.67	1.08	1.36	0.61	0.97	1.21	0.17	0.14	0.09
13	Ferrous metal prod.	0.56	0.96	1.23	0.50	0.86	1.09	0.22	0.20	0.14
14	Motor veh. & equip.	0.53	0.85	1.06	0.49	0.78	0.97	0.07	0.08	0.06
15	Other manufacture.	0.56	0.94	1.21	0.50	0.84	1.07	0.00	0.02	0.00
16	Air transport	0.12	0.55	0.89	0.08	0.47	0.77	0.15	0.24	0.20
17	Trade & oth. trans.	0.54	0.95	1.25	0.48	0.84	1.10	-0.09	-0.04	-0.04
18	Rec. cultural sport	0.59	0.98	1.25	0.53	0.88	1.11	0.04	0.04	0.01
19	Oth. market srvces	0.70	1.08	1.36	0.63	0.98	1.21	-0.21	-0.17	-0.14
20	Govt services	0.62	1.02	1.29	0.56	0.92	1.15	-0.01	-0.01	-0.02

Table 3.16B: Change in supply price of primary factors and industry outputs in South Africa – Scenario 1 relative to BaU (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Factor/sector*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
	Land	0.10	0.18	0.24	0.08	0.14	0.17	0.25	0.10	0.04
	Unskilled labour	0.60	0.96	1.23	0.54	0.86	1.10	0.11	0.07	0.06
	Skilled labour	0.69	1.10	1.42	0.62	0.98	1.26	0.12	0.02	0.00
	Capital	0.95	1.32	1.63	0.87	1.20	1.46	-0.54	-0.47	-0.34
	Natural resources	-6.30	-2.88	-1.70	-5.98	-2.77	-1.92	-7.97	-5.04	-3.15
1	Coal mining	-1.58	0.37	1.05	-1.51	0.30	0.88	-2.37	-0.66	-0.16
2	Oil extraction	-0.83	-0.39	0.31	-0.84	-0.47	0.18	-0.81	-0.75	-0.55
3	Gas extr., manufac.	-0.25	0.77	1.13	-0.27	0.68	0.98	-1.44	-0.55	-0.27
4	Petrol. & coal prod.	-0.89	-0.37	0.22	-0.88	-0.45	0.09	-0.54	-0.30	-0.15
5	Electricity	0.14	0.96	1.35	0.11	0.86	1.19	6.36	4.12	2.67
6	Agri., food tobac.	0.63	0.99	1.28	0.57	0.89	1.14	0.02	0.03	0.04
7	Other mining	0.38	0.79	1.07	0.33	0.69	0.92	0.96	0.84	0.65
8	Paper & publishing	0.64	1.00	1.28	0.58	0.90	1.14	0.11	0.10	0.09
9	Chem. rubber plas.	0.62	0.99	1.27	0.56	0.89	1.13	0.28	0.25	0.20
10	Non metal minerals	0.63	1.04	1.34	0.57	0.94	1.19	0.62	0.52	0.40
11	Iron and steel	0.59	1.01	1.30	0.53	0.90	1.16	0.64	0.55	0.42
12	Non ferrous metals	0.75	1.14	1.42	0.68	1.03	1.27	0.25	0.20	0.16
13	Ferrous metal prod.	0.64	1.02	1.30	0.58	0.92	1.16	0.30	0.26	0.21
14	Motor veh. & equip.	0.58	0.88	1.10	0.54	0.82	1.01	0.12	0.12	0.10
15	Other manufacture.	0.64	1.00	1.27	0.58	0.90	1.14	0.08	0.07	0.07
16	Air transport	0.23	0.63	0.99	0.19	0.55	0.87	0.26	0.32	0.30
17	Trade & oth. trans.	0.63	1.01	1.32	0.56	0.91	1.17	0.00	0.02	0.04
18	Rec. cultural sport	0.66	1.02	1.31	0.59	0.92	1.17	0.10	0.08	0.07
19	Oth. market srvces	0.76	1.13	1.42	0.70	1.02	1.27	-0.14	-0.12	-0.08
20	Govt services	0.67	1.03	1.32	0.61	0.93	1.18	0.04	0.01	0.01

Table 3.17 shows the (absolute) percentage change in regional GDP price index. Since all prices are relative to the numeraire, which in our case is the *average* percentage change in factor prices of all regions, and since we assume that this numeraire remains unchanged throughout all simulations[37], the change in regional GDP prices measures the movement in the general price level of each region relative to that of the world as a whole. Thus, if we compare the change in GDP price of the USA against that of South Africa, then we get a measure of the 'relative inflation' between these two regions. If we also assume that movement in the 'real' exchange rate is determined primarily by movements in relative purchasing power, then we get movements in real exchange rate from movements in this 'relative inflation' index.[38]

[37] If we shock this numeraire, then this simply shifts all price levels in all regions by the same percentage, hence leaving all relative prices unchanged.

[38] Because of the system of single European currency for most European Union (EU) countries, the term 'real exchange rate' here should simply imply 'real purchasing power' from factor income, because it represents the relative movements in factor prices

Table 3.17: Change in GDP price index for all regions – Scenario 1 (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.59	1.04	1.34	0.53	0.93	1.19	0.00	0.03	0.01
2	USA	0.29	0.38	0.44	0.16	0.13	0.06	0.21	0.22	0.19
3	Germany	0.60	0.78	0.86	0.56	0.74	0.81	0.39	0.38	0.33
4	UK	0.46	0.56	0.57	0.41	0.53	0.56	0.32	0.32	0.28
5	Netherlands	0.37	0.40	0.33	0.45	0.54	0.50	0.37	0.36	0.32
6	France	0.49	0.59	0.63	0.60	0.80	0.90	0.40	0.40	0.34
7	Italy	0.56	0.71	0.78	0.58	0.79	0.92	0.40	0.39	0.34
8	Belgium	0.74	0.87	0.87	0.72	0.91	0.95	0.51	0.52	0.46
9	W Europe	0.49	0.60	0.59	0.51	0.66	0.70	0.35	0.34	0.29
10	EFTA	0.25	0.52	0.74	0.25	0.50	0.68	0.17	0.20	0.19
11	Russia	-0.62	-0.52	-0.52	-0.65	-0.61	-0.69	-0.49	-0.42	-0.38
12	Japan	0.46	0.45	0.38	0.65	0.85	1.09	0.51	0.51	0.46
13	Aus., NZ, Canada	0.18	0.30	0.38	0.08	0.15	0.16	0.11	0.15	0.13
14	Rest Annex I	0.49	0.37	-0.40	0.38	0.14	-0.83	0.33	0.31	0.27
15	China & HK	-0.08	0.15	0.44	-0.12	0.09	0.35	-0.51	-0.57	-0.49
16	India	0.28	0.60	1.09	0.21	0.49	0.93	-0.34	-0.47	-0.37
17	Bra., Arg., Para.	0.64	1.10	1.55	0.55	0.96	1.35	0.09	0.09	0.05
18	Africa	-0.54	-0.10	0.36	-0.58	-0.19	0.22	-0.53	-0.41	-0.34
19	Middle East	-0.31	0.07	0.42	-0.34	-0.01	0.30	-0.39	-0.32	-0.28
20	Rest of world	0.21	0.52	0.75	0.16	0.44	0.64	-0.08	-0.07	-0.10

Table 3.18A presents the absolute movements in real exchange rate between South Africa and other regions while Table 3.18B reports the movements *relative* to BaU scenario. Both shows that the real exchange rate between South Africa and other regions will depreciate for the cases of 'No ET' and 'Annex I ET' (except for 'Brazil, Argentina, Paraguay', and also Belgium, but only for the first period 2004-2010). Only in the case of 'Annex I trading and NAI no-lose crediting' that the situation is reversed and South African Rand will appreciate against other currencies (except for the currencies of Russia, China & HK, India, Africa, and Middle East).

The adverse movement in real exchange rate for South Africa can be partly attributed to adverse movements in factor prices in South Africa relative to other regions (Table 3.19a). This in turn can be partly attributed to strong demand for factors in South Africa relative to other regions (Tables 3.20A-C) – with the exception of the demand for capital in other NAI regions which shows stronger movements than in South Africa (see Table 3.20A). This can also be the net result of two conflicting trends in South Africa as discussed above: energy-efficiency substitution (which encourages demand for capital) and shifts from energy-intensive to non energy intensive activities (which encourages demand for labour). The impact of response measures in South Africa seems to be a stronger (activity) compositional effect as compared to energy-capital substitution effect. Hence, employment is expected to increase in this scenario.

Table 3.18A: Differences in percentage change of GDP price index or movement in real exchange rate between South African Rand and other regions – Scenario 1 (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	USA	-0.30	-0.66	-0.90	-0.37	-0.80	-1.13	0.21	0.18	0.18
3	Germany	0.00	-0.27	-0.48	0.04	-0.19	-0.38	0.38	0.35	0.31
4	UK	-0.13	-0.48	-0.77	-0.11	-0.40	-0.63	0.31	0.29	0.27
5	Netherlands	-0.23	-0.64	-1.01	-0.08	-0.39	-0.69	0.36	0.33	0.31
6	France	-0.10	-0.45	-0.72	0.07	-0.14	-0.29	0.40	0.37	0.33
7	Italy	-0.03	-0.33	-0.57	0.05	-0.14	-0.27	0.39	0.36	0.33
8	Belgium	0.14	-0.18	-0.47	0.19	-0.02	-0.24	0.51	0.49	0.45
9	W Europe	-0.10	-0.44	-0.75	-0.02	-0.27	-0.49	0.35	0.31	0.28
10	EFTA	-0.35	-0.52	-0.61	-0.28	-0.43	-0.51	0.16	0.17	0.17
11	Russia	-1.22	-1.56	-1.86	-1.17	-1.54	-1.88	-0.49	-0.45	-0.39
12	Japan	-0.13	-0.59	-0.97	0.12	-0.08	-0.10	0.51	0.48	0.44
13	Aus., NZ, Canada	-0.41	-0.74	-0.96	-0.44	-0.78	-1.03	0.11	0.12	0.12
14	Rest Annex I	-0.11	-0.67	-1.74	-0.15	-0.80	-2.02	0.33	0.28	0.26
15	China & HK	-0.67	-0.89	-0.90	-0.65	-0.84	-0.84	-0.51	-0.60	-0.50
16	India	-0.31	-0.44	-0.26	-0.32	-0.44	-0.26	-0.34	-0.50	-0.38
17	Bra., Arg., Para.	0.04	0.06	0.21	0.02	0.03	0.16	0.08	0.06	0.04
18	Africa	-1.14	-1.14	-0.98	-1.11	-1.12	-0.97	-0.53	-0.44	-0.35
19	Middle East	-0.91	-0.98	-0.93	-0.87	-0.95	-0.89	-0.40	-0.35	-0.30
20	Rest of world	-0.39	-0.53	-0.59	-0.37	-0.50	-0.55	-0.08	-0.10	-0.12

Table 3.18B: Differences in percentage change of GDP price index or movement in real exchange rate between South African rand and other regions – Scenario 1 relative to BaU (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	USA	-0.44	-0.78	-1.03	-0.50	-0.92	-1.26	0.07	0.07	0.05
3	Germany	-0.18	-0.43	-0.65	-0.15	-0.36	-0.55	0.20	0.19	0.14
4	UK	-0.31	-0.65	-0.95	-0.30	-0.57	-0.81	0.13	0.12	0.09
5	Netherlands	-0.43	-0.82	-1.20	-0.28	-0.57	-0.88	0.16	0.15	0.12
6	France	-0.27	-0.60	-0.88	-0.11	-0.29	-0.45	0.23	0.21	0.17
7	Italy	-0.21	-0.49	-0.74	-0.13	-0.30	-0.44	0.21	0.20	0.16
8	Belgium	-0.17	-0.48	-0.78	-0.12	-0.33	-0.54	0.20	0.18	0.14
9	W Europe	-0.28	-0.60	-0.91	-0.19	-0.42	-0.65	0.17	0.16	0.12
10	EFTA	-0.48	-0.64	-0.74	-0.41	-0.56	-0.64	0.03	0.05	0.05
11	Russia	-1.03	-1.39	-1.69	-0.99	-1.37	-1.71	-0.31	-0.28	-0.22
12	Japan	-0.38	-0.82	-1.20	-0.13	-0.31	-0.33	0.26	0.25	0.21
13	Aus., NZ, Canada	-0.52	-0.83	-1.06	-0.55	-0.87	-1.13	0.01	0.03	0.03
14	Rest Annex I	-0.31	-0.85	-1.93	-0.35	-0.98	-2.21	0.13	0.10	0.07
15	China & HK	-0.18	-0.37	-0.51	-0.16	-0.33	-0.45	-0.02	-0.09	-0.11
16	India	0.09	0.02	0.06	0.08	0.02	0.06	0.05	-0.04	-0.07

		No ET			Annex 1 ET			Annex I ET with NAI no-lose crediting		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
17	Bra., Arg., Para.	0.07	0.09	0.23	0.05	0.06	0.19	0.10	0.09	0.07
18	Africa	-0.98	-1.01	-0.84	-0.95	-0.99	-0.83	-0.38	-0.31	-0.21
19	Middle East	-0.80	-0.89	-0.83	-0.77	-0.86	-0.80	-0.29	-0.27	-0.20
20	Rest of world	-0.26	-0.39	-0.46	-0.25	-0.37	-0.42	0.04	0.03	0.01

Table 3.19A: Relative movement in factor prices (% change in other region – % change in South Africa – Scenario 1 (average % per annum)

		No ET			Annex 1 ET			Annex I ET with NAI no-lose crediting		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	USA	-0.72	-1.19	-1.50	-0.83	-1.44	-1.88	0.45	0.37	0.31
3	Germany	-0.30	-0.69	-0.98	-0.23	-0.58	-0.84	0.73	0.62	0.52
4	UK	-0.37	-0.92	-1.36	-0.37	-0.80	-1.14	0.65	0.56	0.47
5	Netherlands	-0.87	-1.56	-2.13	-0.46	-1.02	-1.51	0.69	0.59	0.50
6	France	-0.53	-1.10	-1.47	-0.08	-0.41	-0.65	0.79	0.68	0.56
7	Italy	-0.50	-1.01	-1.40	-0.19	-0.52	-0.73	0.74	0.64	0.54
8	Belgium	-0.32	-0.85	-1.28	-0.04	-0.39	-0.70	0.86	0.77	0.67
9	W Europe	-0.59	-1.19	-1.67	-0.30	-0.71	-1.04	0.68	0.57	0.47
10	EFTA	-0.71	-0.97	-1.10	-0.50	-0.74	-0.87	0.49	0.43	0.36
11	Russia	-3.40	-5.07	-6.70	-3.59	-5.31	-6.91	-0.94	-0.97	-0.86
12	Japan	-0.53	-1.20	-1.73	-0.10	-0.41	-0.50	0.85	0.75	0.65
13	Aus., NZ, Canada	-0.89	-1.42	-1.75	-0.96	-1.51	-1.90	0.34	0.29	0.24
14	Rest Annex I	-1.17	-2.40	-4.47	-1.50	-2.80	-4.84	0.30	0.22	0.20
15	China & HK	-0.73	-0.95	-0.95	-0.70	-0.90	-0.89	-0.86	-1.00	-0.86
16	India	-0.27	-0.41	-0.22	-0.28	-0.41	-0.22	-0.38	-0.62	-0.51
17	Bra., Arg., Para.	0.05	0.07	0.23	0.03	0.04	0.18	0.29	0.21	0.14
18	Africa	-1.23	-1.22	-1.05	-1.20	-1.21	-1.04	-0.40	-0.38	-0.34
19	Middle East	-0.96	-1.02	-0.97	-0.92	-0.99	-0.93	-0.48	-0.51	-0.46
20	Rest of world	-0.40	-0.54	-0.60	-0.38	-0.51	-0.55	0.03	-0.05	-0.10

Table 3.19B: Relative movement in factor prices (% change in other region – % change in South Africa – Scenario 1 *Relative* to BaU (average % per annum)

		No ET			Annex 1 ET			Annex I ET with NAI no-lose crediting		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	USA	-0.85	-1.31	-1.62	-0.96	-1.56	-2.00	0.32	0.25	0.19
3	Germany	-0.50	-0.87	-1.16	-0.43	-0.76	-1.02	0.53	0.44	0.34
4	UK	-0.58	-1.10	-1.55	-0.57	-0.98	-1.33	0.45	0.37	0.28
5	Netherlands	-1.10	-1.77	-2.35	-0.70	-1.24	-1.73	0.46	0.37	0.28
6	France	-0.72	-1.27	-1.65	-0.28	-0.58	-0.82	0.60	0.51	0.39
7	Italy	-0.69	-1.19	-1.58	-0.39	-0.69	-0.92	0.54	0.46	0.36
8	Belgium	-0.66	-1.18	-1.61	-0.37	-0.72	-1.04	0.53	0.44	0.33

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
9	W Europe	-0.78	-1.36	-1.84	-0.49	-0.88	-1.22	0.49	0.40	0.30
10	EFTA	-0.84	-1.09	-1.23	-0.63	-0.87	-1.00	0.35	0.30	0.24
11	Russia	-3.21	-4.89	-6.52	-3.41	-5.13	-6.73	-0.75	-0.79	-0.68
12	Japan	-0.79	-1.43	-1.97	-0.36	-0.65	-0.74	0.59	0.52	0.41
13	Aus., NZ, Canada	-1.00	-1.51	-1.85	-1.06	-1.60	-1.99	0.23	0.20	0.15
14	Rest Annex I	-1.39	-2.60	-4.68	-1.72	-3.00	-5.05	0.08	0.02	-0.01
15	China & HK	-0.20	-0.39	-0.53	-0.18	-0.35	-0.47	-0.34	-0.45	-0.44
16	India	0.16	0.09	0.12	0.15	0.09	0.11	0.05	-0.12	-0.17
17	Bra., Arg., Para.	0.07	0.10	0.26	0.05	0.07	0.21	0.32	0.24	0.17
18	Africa	-1.06	-1.09	-0.90	-1.03	-1.07	-0.89	-0.24	-0.25	-0.19
19	Middle East	-0.85	-0.93	-0.87	-0.81	-0.90	-0.83	-0.37	-0.42	-0.36
20	Rest of world	-0.26	-0.39	-0.46	-0.24	-0.36	-0.41	0.17	0.09	0.04

Table 3.20A: Relative movement in demand for capital (% change in other region – % change in South Africa – Scenario 1 (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	USA	-0.46	-0.22	-0.09	-0.43	-0.15	0.04	-0.92	-0.86	-0.84
3	Germany	-0.94	-0.73	-0.64	-0.96	-0.77	-0.69	-1.36	-1.28	-1.24
4	UK	-0.89	-0.60	-0.41	-0.87	-0.64	-0.51	-1.30	-1.23	-1.19
5	Netherlands	-0.57	-0.16	0.13	-0.83	-0.52	-0.28	-1.34	-1.27	-1.23
6	France	-0.76	-0.47	-0.32	-0.99	-0.82	-0.73	-1.34	-1.27	-1.22
7	Italy	-0.80	-0.53	-0.37	-0.95	-0.79	-0.70	-1.33	-1.26	-1.22
8	Belgium	-0.78	-0.49	-0.30	-0.94	-0.74	-0.61	-1.32	-1.25	-1.21
9	W Europe	-0.74	-0.41	-0.20	-0.90	-0.69	-0.57	-1.30	-1.23	-1.19
10	EFTA	-0.78	-0.61	-0.54	-0.89	-0.73	-0.66	-1.26	-1.20	-1.16
11	Russia	1.49	2.47	3.81	1.57	2.67	4.07	0.69	0.71	0.74
12	Japan	-0.77	-0.48	-0.28	-0.91	-0.73	-0.65	-1.29	-1.22	-1.18
13	Aus., NZ, Canada	-0.42	-0.13	0.05	-0.40	-0.09	0.14	-0.92	-0.87	-0.84
14	Rest Annex I	-0.54	0.20	1.61	-0.33	0.52	1.99	-1.16	-1.08	-1.06
15	China & HK	3.14	3.13	2.42	3.13	3.12	2.41	3.18	3.18	2.42
16	India	2.01	2.19	1.46	2.00	2.18	1.45	2.00	2.18	1.44
17	Bra., Arg., Para.	0.03	0.04	0.04	0.03	0.03	0.03	-0.12	-0.13	-0.09
18	Africa	0.14	0.12	0.09	0.14	0.12	0.10	-0.03	-0.06	-0.05
19	Middle East	0.05	0.05	0.07	0.04	0.05	0.07	0.00	0.00	0.02
20	Rest of world	0.76	0.75	0.75	0.76	0.75	0.74	0.62	0.59	0.60

Table 3.20B: Relative movement in demand for skilled labour (% change in other region – % change in South Africa – Scenario 1 (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	USA	-0.80	-0.67	-0.62	-0.78	-0.62	-0.53	-0.75	-0.73	-0.74
3	Germany	-1.12	-1.01	-1.00	-1.12	-1.01	-1.00	-1.06	-1.03	-1.03
4	UK	-1.14	-1.00	-0.93	-1.12	-1.00	-0.96	-1.07	-1.04	-1.05
5	Netherlands	-0.97	-0.76	-0.64	-1.07	-0.92	-0.84	-1.07	-1.05	-1.05
6	France	-1.05	-0.91	-0.87	-1.11	-1.02	-1.01	-1.05	-1.02	-1.03
7	Italy	-1.07	-0.95	-0.92	-1.06	-0.95	-0.92	-0.99	-0.97	-0.98
8	Belgium	-1.07	-0.94	-0.89	-1.09	-0.99	-0.96	-1.02	-1.00	-1.00
9	W Europe	-1.07	-0.93	-0.88	-1.10	-1.01	-0.99	-1.04	-1.02	-1.02
10	EFTA	-1.09	-0.99	-0.97	-1.10	-1.01	-1.00	-1.03	-1.01	-1.01
11	Russia	1.14	1.97	3.15	1.22	2.17	3.41	0.85	0.83	0.82
12	Japan	-1.09	-0.99	-0.95	-1.08	-0.99	-0.95	-1.01	-0.98	-0.99
13	Aus., NZ, Canada	-0.82	-0.68	-0.61	-0.81	-0.66	-0.57	-0.75	-0.74	-0.75
14	Rest Annex I	-1.12	-0.91	-0.61	-1.12	-0.83	-0.52	-1.04	-1.00	-1.00
15	China & HK	2.96	2.93	2.22	2.96	2.93	2.22	2.88	2.84	2.14
16	India	1.97	2.14	1.45	1.96	2.14	1.44	1.92	2.04	1.33
17	Bra., Arg., Para.	-0.01	-0.02	-0.01	-0.01	-0.02	-0.01	0.04	-0.01	-0.02
18	Africa	-0.11	-0.06	-0.01	-0.11	-0.07	-0.02	-0.12	-0.16	-0.14
19	Middle East	-0.10	-0.07	-0.03	-0.11	-0.08	-0.04	-0.14	-0.16	-0.14
20	Rest of world	0.68	0.66	0.63	0.68	0.66	0.64	0.70	0.63	0.60

Table 3.20C: Relative movement in demand for unskilled labour (% change in other region – % change in South Africa – Scenario 1 (average % per annum)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	USA	-0.81	-0.69	-0.64	-0.80	-0.65	-0.56	-0.77	-0.76	-0.76
3	Germany	-1.11	-1.00	-0.97	-1.11	-1.00	-0.98	-1.07	-1.05	-1.05
4	UK	-1.14	-1.00	-0.92	-1.12	-1.00	-0.95	-1.09	-1.07	-1.06
5	Netherlands	-0.97	-0.75	-0.62	-1.07	-0.91	-0.82	-1.09	-1.06	-1.06
6	France	-1.05	-0.91	-0.87	-1.11	-1.01	-0.99	-1.06	-1.04	-1.04
7	Italy	-1.06	-0.93	-0.88	-1.05	-0.94	-0.89	-1.00	-0.98	-0.99
8	Belgium	-1.07	-0.93	-0.87	-1.09	-0.99	-0.95	-1.04	-1.02	-1.02
9	W Europe	-1.08	-0.93	-0.86	-1.11	-1.01	-0.98	-1.06	-1.04	-1.04
10	EFTA	-1.09	-0.98	-0.96	-1.11	-1.02	-0.99	-1.06	-1.03	-1.04
11	Russia	1.18	2.03	3.23	1.25	2.22	3.48	0.85	0.83	0.82
12	Japan	-1.11	-0.99	-0.94	-1.11	-1.02	-0.99	-1.05	-1.03	-1.03
13	Aus., NZ, Canada	-0.82	-0.69	-0.61	-0.81	-0.66	-0.57	-0.78	-0.76	-0.77
14	Rest Annex I	-1.12	-0.91	-0.60	-1.11	-0.83	-0.52	-1.06	-1.02	-1.01
15	China & HK	3.04	2.98	2.23	3.04	2.98	2.24	3.02	2.99	2.26
16	India	1.97	2.12	1.38	1.97	2.12	1.38	2.02	2.16	1.42

		No ET			Annex 1 ET			Annex I ET with NAI no-lose crediting		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
17	Bra., Arg., Para.	-0.03	-0.05	-0.05	-0.03	-0.04	-0.05	0.02	-0.03	-0.03
18	Africa	-0.11	-0.07	0.00	-0.12	-0.08	-0.02	-0.13	-0.17	-0.15
19	Middle East	-0.10	-0.06	-0.01	-0.10	-0.07	-0.03	-0.14	-0.16	-0.14
20	Rest of world	0.68	0.64	0.61	0.68	0.65	0.62	0.70	0.63	0.61

3.3.3 Scenario 2: Annex I CO_2 reduction of 40% below 1990 levels by 2020

So far, the analysis of Scenario 1 results showed that there is an important shift in the pattern of economic activity and trade in the South African economy and in particular on the energy intensive and trade intensive sectors, when the emissions trade arrangement is changed from 'No ET' or 'Annex I ET' to one with 'no-lose credit' arrangement that allows NAI countries to earn credit for their efforts to reduce rather than to increase their own emissions in response to Annex I regions implementing climate policy measures. The reason is that the world as a whole can benefit from increased efficiency of climate policy, lower relative costs and these benefits can flow on to all countries, including South Africa. Efficiency gains do not, however, address issues of equitable distribution of gains from trade across countries. The benefits of increased climate policy efficiency can be said to come from three sources:

iv) *Output or production expansion effect*, which sees the world economic output and hence world demand for exports and imports increased, even if the same climate policy target (for the world as a whole) is maintained.

v) *Production efficiency effect*, which sees a switch from energy (and emissions) inefficient production activities to energy-efficient activities. This allows NAI countries to reduce their emissions (at least in relative terms), rather than increasing them, and this can bring benefits both to NAI regions as well as Annex I regions. Emissions can be reduced in the regions where it is most cost-effective to do so, meaning more mitigation takes place overall. Increased global mitigation has benefits for all countries in avoiding greater climate impacts, to which poor countries and communities are particularly vulnerable. This is the 'gains from (emission) trade' effect even if 'trade' here is still limited because it is confined only to a form of 'no-lose credit' given to NAI efforts at reducing emissions rather than by an explicit allocation of emissions permits.

vi) *Consumption efficiency effect*, which sees a switch of consumption activities from energy and emission intensive commodities/activities to less energy-intensive ones, even if the same level of welfare is maintained.

Depending on how these three effects interact, the impacts on South African energy-intensive and trade-intensive sectors will differ as analysed under Scenario 1. Overall, the results of Scenario 2 help to reinforce the results of Scenario 1. They show that even with significant changes in the climate policy target (from 25% reduction to 40% reduction below 1990 emissions level for Annex I regions) the patterns of the impacts on South Africa do not change in any significant way even though the magnitudes of the impacts will change (as expected). There is however a significant shift in the patterns of impacts when there is a change in emissions trading regime from 'Annex I ET' to 'Annex I ET *with* NAI no-lose crediting' remains with Scenario 2 as in Scenario 1.

Emissions, leakage, marginal abatement costs, savings from emissions trade

First, with respect to the issue of emissions and marginal abatement costs, and leakage rates, increasing the Annex I target emissions reduction from -25% below 1990 to -40% below 1990 clearly will increase both the MACs and the leakage rates, as can be seen from Tables 3.21 and 3.22. However, the overall pattern of impacts remains the same. In particular, the 'switching of regime' from one of emissions leakage from Annex I to no-Annex I regions (when there is Annex I ET but *without* 'NAI no-lose crediting') to one with no leakage but with a positive contribution by NAI regions to the overall emissions reduction effort of the world as a whole (when there is Annex I ET but *with* 'NAI no-lose crediting') is maintained, if not reinforced.

The previous leakage rates of around 12% to 14% p.a. has now increased to 12% to 16% if there is no 'NAI no-lose crediting'). With 'NAI no-lose crediting', leakage becomes 'positive' in the sense that there is now a positive contribution by NAI regions to the overall emissions reduction which is equal to 133% to 146% the size of Annex I reductions (instead of 138% to 153% in Scenario 1). Because the MACs are now much higher than before, and also the changes in emissions levels are also much greater, the potential savings in emissions abatement costs when there is Annex I ET (with or without 'NAI no-lose crediting') is also much higher (Table 3.23). Total savings is almost double or even triple in some cases (Annex I ET in the period ending 2020). The gains from emission no-lose crediting for SA is also higher: $469.8 million per annum instead of $284.8 million per annum in the period 2004-2010, even though the gains return to previous levels of around $67.7 million in the period 2015-2020.

Table 3.21: CO_2 Emission for Scenario 2 (Gt C)

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No.	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.12	0.15	0.16	0.12	0.15	0.16	0.08	0.08	0.08
2	USA	1.40	1.18	1.00	1.34	1.08	0.87	1.68	1.72	1.81
3	Germany	0.18	0.15	0.13	0.19	0.16	0.14	0.22	0.23	0.24
4	UK	0.14	0.12	0.10	0.14	0.12	0.10	0.16	0.17	0.18
5	Netherlands	0.05	0.04	0.03	0.05	0.05	0.04	0.06	0.06	0.07
6	France	0.09	0.07	0.06	0.10	0.09	0.09	0.11	0.12	0.13
7	Italy	0.10	0.09	0.07	0.12	0.10	0.09	0.13	0.14	0.14
8	Belgium	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.03
9	W Europe	0.18	0.15	0.13	0.20	0.18	0.16	0.23	0.24	0.25
10	EFTA	0.03	0.02	0.02	0.03	0.03	0.02	0.03	0.03	0.04
11	Russia	0.36	0.30	0.26	0.34	0.28	0.18	0.44	0.46	0.51
12	Japan	0.25	0.21	0.18	0.28	0.26	0.24	0.32	0.34	0.36
13	Aus., NZ, Canada	0.22	0.19	0.16	0.22	0.18	0.15	0.26	0.27	0.29
14	Rest Annex I	0.30	0.26	0.22	0.29	0.25	0.27	0.35	0.36	0.37
15	China & HK	1.70	2.22	2.80	1.70	2.22	2.80	1.31	1.48	1.72
16	India	0.38	0.48	0.58	0.38	0.48	0.58	0.32	0.36	0.41
17	Bra., Arg., Para.	0.15	0.17	0.18	0.15	0.17	0.19	0.13	0.15	0.16
18	Africa	0.03	0.03	0.04	0.03	0.03	0.04	0.02	0.03	0.03
19	Middle East	0.61	0.73	0.85	0.61	0.73	0.91	0.53	0.57	0.63
20	Rest of world	1.18	1.43	1.72	1.18	1.43	1.75	1.06	1.19	1.35
Annex 1 Total		3.32	2.81	2.37	3.32	2.80	2.37	4.03	4.17	4.42
% change over 1990 level		-16.1	-29.0	-40.0	-16.1	-29.2	-40.1	1.9	5.4	11.7
% change over pvs period		-15.4	-15.4	-15.4	-15.4	-15.6	-15.4	2.7	3.4	6.0
Non-Annex1 Total		4.17	5.22	6.33	4.17	5.22	6.43	3.46	3.85	4.38
% change over pvs period		31.7	25.0	21.4	31.6	25.1	23.2	9.2	11.3	13.8
World Total		7.49	8.02	8.71	7.49	8.02	8.80	7.49	8.02	8.80
% change over pvs period		5.6	7.1	8.5	5.6	7.1	9.7	5.6	7.1	9.7
leakage rate (from Annex I to NAI) (%)		-12.1%	-13.2%	-12.8%	-11.8%	-13.2%	-15.9%	133%	138%	146%

Table 3.22: Marginal abatement cost or CO_2 emission permit price (2004 $/tC) for Scenario 2

		No ET			*Annex 1 ET*			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0	0	0	0	0	0	79	147	194
2	USA	234	596	1154	273	740	1443	79	147	194
3	Germany	309	843	1625	273	740	1443	79	147	194
4	UK	273	824	1704	273	740	1443	79	147	194
5	Netherlands	428	1122	2190	273	740	1443	79	147	194
6	France	650	1749	3355	273	740	1443	79	147	194
7	Italy	510	1437	2973	273	740	1443	79	147	194
8	Belgium	534	1469	2930	273	740	1443	79	147	194
9	W Europe	484	1363	2770	273	740	1443	79	147	194
10	EFTA	499	1289	2516	273	740	1443	79	147	194
11	Russia	226	621	1273	273	740	1443	79	147	194
12	Japan	519	1478	3124	273	740	1443	79	147	194
13	Aus., NZ, Canada	252	678	1338	273	740	1443	79	147	194
14	Rest Annex I	219	667	1631	273	740	1443	79	147	194
15	China & HK	0	0	0	0	0	0	79	147	194
16	India	0	0	0	0	0	0	79	147	194
17	Bra., Arg., Para.	0	0	0	0	0	0	79	147	194
18	Africa	0	0	0	0	0	0	79	147	194
19	Middle East	0	0	0	0	0	0	79	147	194
20	Rest of world	0	0	0	0	0	0	79	147	194

Table 3.23: Values of emissions trade (2004 $ million) (annual average) for Scenario 2

		Annex 1 ET			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
1	South Africa	0.0	0.0	0.0	469.8	186.8	67.7
2	USA	2610	5441	4288	3651	4049	3359
3	Germany	204	245	430	523	564	452
4	UK	10	358	607	342	395	324
5	Netherlands	207	184	264	157	165	128
6	France	669	849	1070	328	342	261
7	Italy	751	229	38	346	366	283
8	Belgium	150	192	293	85	90	69
9	W Europe	935	1226	1572	611	643	498
10	EFTA	139	123	50	88	91	70
11	Russia	908	597	10056	1069	1265	1107
12	Japan	1351	1818	2822	869	911	704
13	Aus., NZ, Canada	180	259	389	586	664	544
14	Rest Annex I	696	582	7588	657	792	662
15	China & HK	0	0	0	4523	2864	1258
16	India	0	0	0	804	480	206
17	Bra., Arg., Para.	0	0	0	133	100	49
18	Africa	0	0	0	21	17	8

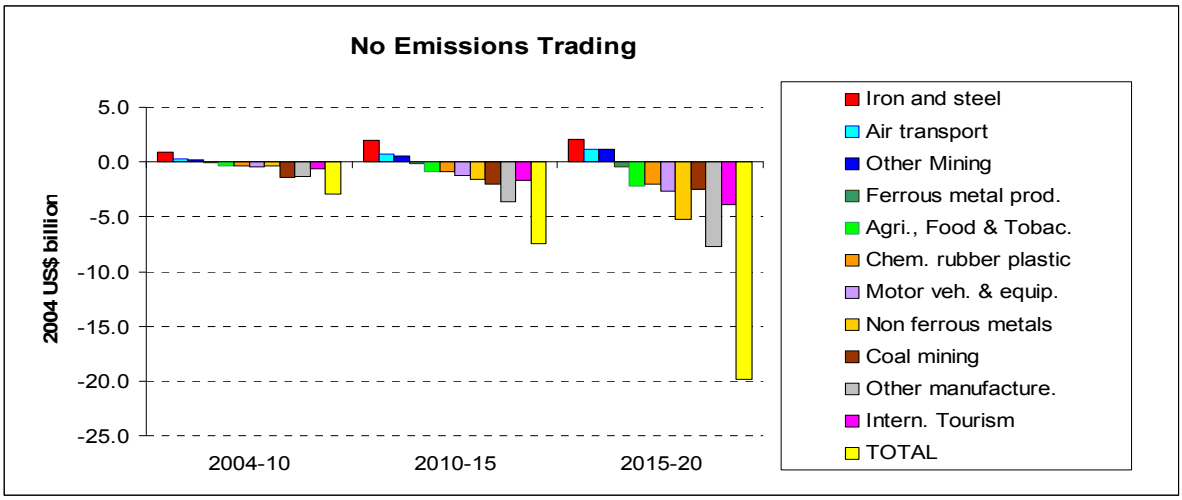
		Annex 1 ET			*Annex I ET with NAI no-lose crediting*		
No	*Region*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
19	Middle East	0	0	0	654	524	255
20	Rest of world	0	0	0	933	788	394
	Total	8809	12105	29466	16852	15297	10698

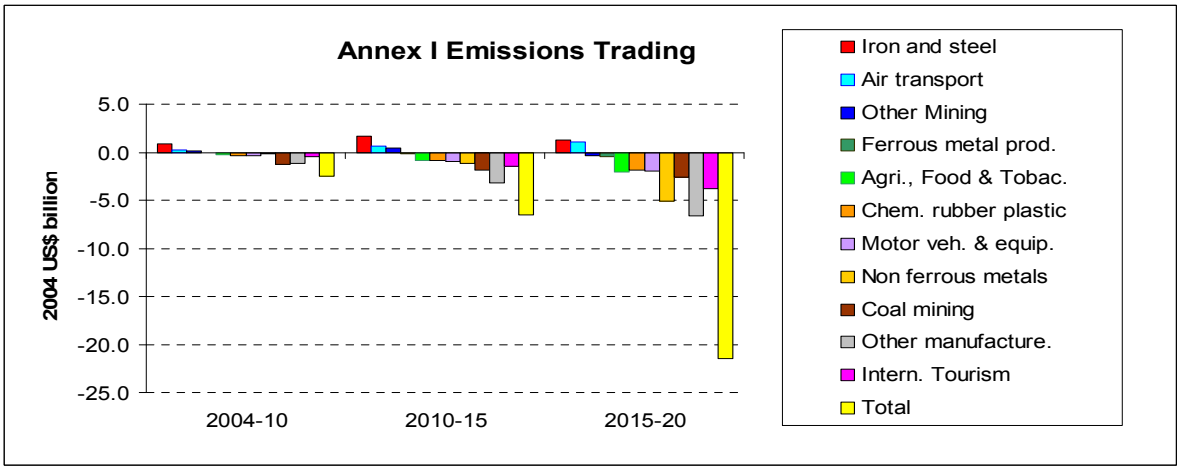
Specific losses or gains in some important South African export sectors

Next, with respect to the issue of specific losses or gains by sectors for the South African economy Figure 3.14 (as compared to Figure 3.10) shows that although the magnitudes of the gains and losses are now much higher (especially for the cases of 'No ET' and 'Annex I ET', the patterns of the impacts remain the same, and also the switching of regime from one of mostly *negative* impacts when there is no 'NAI no-lose crediting' to one of mostly *positive* impacts when there *is* 'NAI no-lose crediting'. Interestingly, even if the magnitude of the overall losses in the cases of No ET and Annex I ET are now much higher ($20 billion per annum in the period ending 2020, instead of the previous $9 billion per annum), the magnitudes of the net gains for the case of 'Annex I ET with no-lose crediting' remain essentially of the same order ($5.2 billion instead of $4.4 billion in the period ending 2020). This implies that with the case of 'Annex I ET with no-lose crediting', the results are much less sensitive to the emissions reduction target of Annex I regions as compared to the cases of 'No ET' and 'Annex I ET'. One of the reasons for this greater sensitivity in the cases of 'No ET' and 'Annex I ET' as compared to the case of 'Annex I ET with no-lose crediting' is that in the former cases, with no (or little) co-operation between regions, there is a much smaller 'base' of emissions on which to work the reductions on, hence the results will be rather sensitive to the size of the target (relative to the base). This is in contrast to the latter case (Scenario 'C') when there is wider co-operation and hence a much larger emissions base to work the reduction target on. As a result, the relative size of the target (compared to the base) will be much smaller (even though in absolute terms it is still of the same magnitude). [39]

[39] Note that the analysis in this section does not take into account the 'extra value' of climate change prevention on International tourism which was estimated for Scenario 1 in Section 3.3.2 but which can also be assumed to apply to Scenario 2. These 'extra value' can be added to the gains/losses discussed in this section to arrive at a 'net' gains/losses if we assume that Scenario 2 can prevent climate change impacts (as assumed in the Hamilton *et al*. (2005) study) on International tourism completely.

Figure 3.14: Scenario 2 – Specific export losses or gains in South African export sectors – Scenario 1 relative to BaU (total for each period in 2004 $ billion)





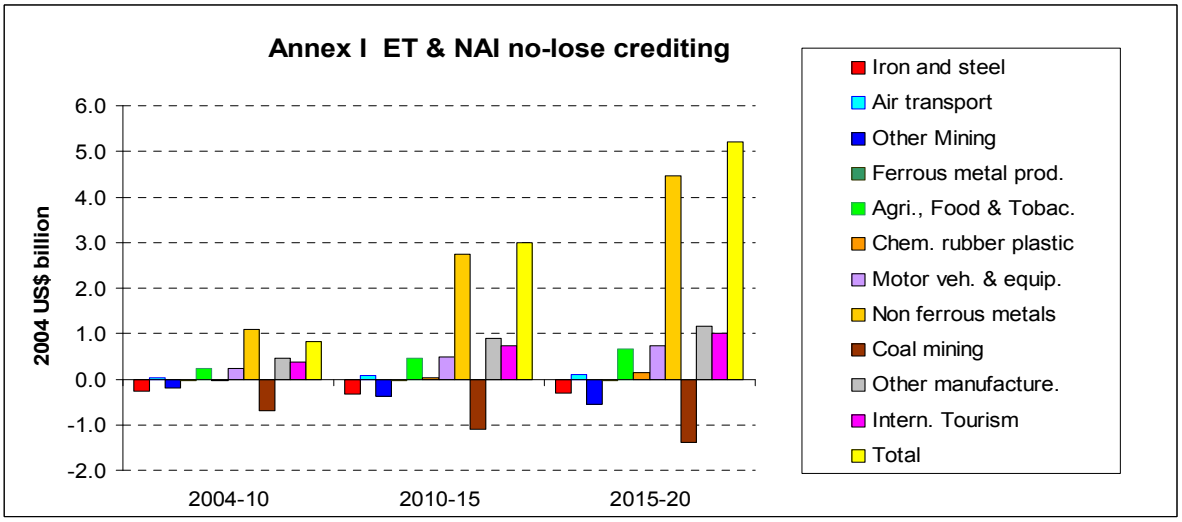
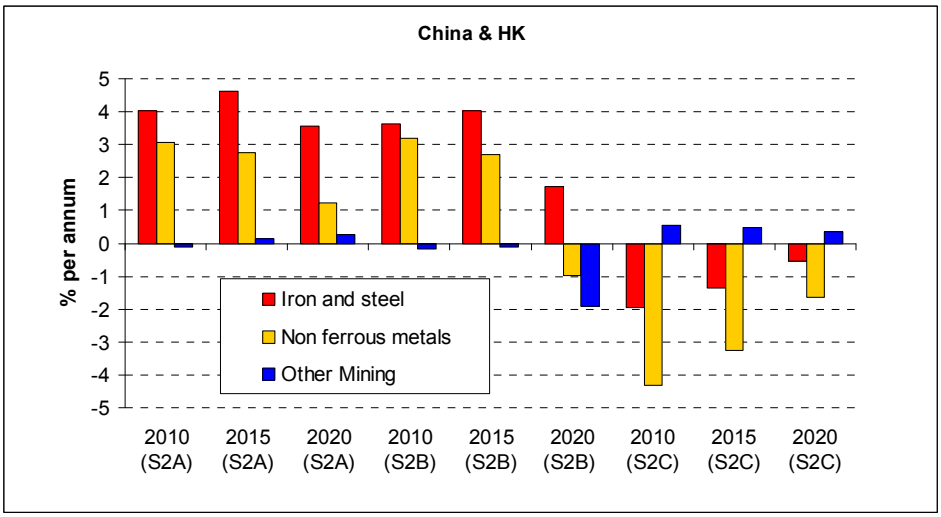
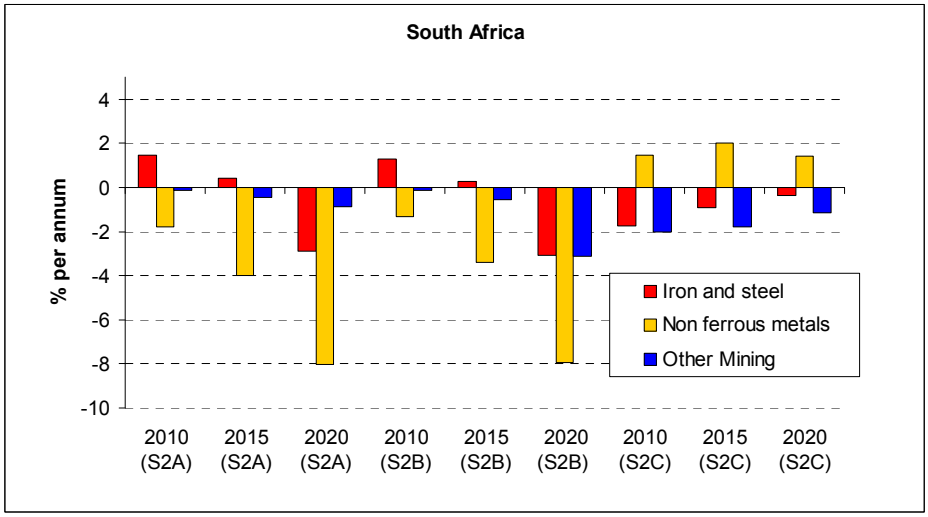


Figure 3.14: Scenario 2 – Specific export losses or gains in South African export sectors – Scenario 1 relative to BaU (total for each period in 2004 $ billion)





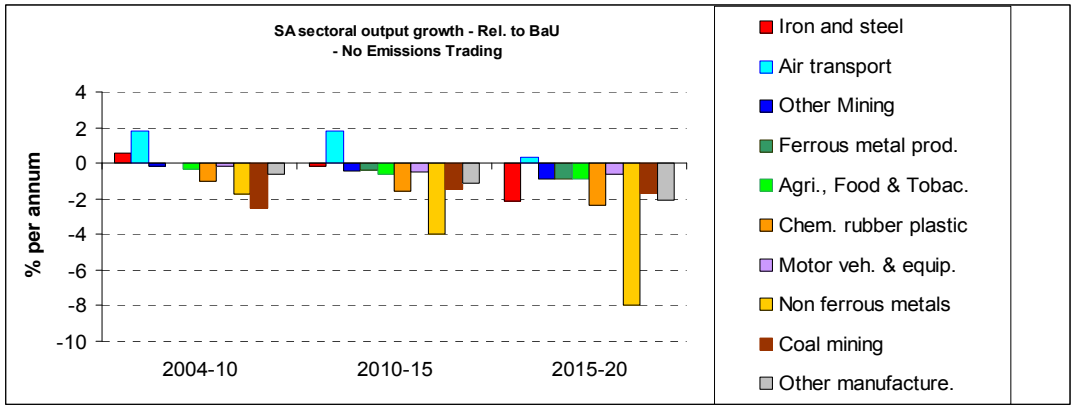
(S2): Scenario 2; (A) No ET; (B): Annex I ET; (C): Annex I ET with NAI no-lose crediting.

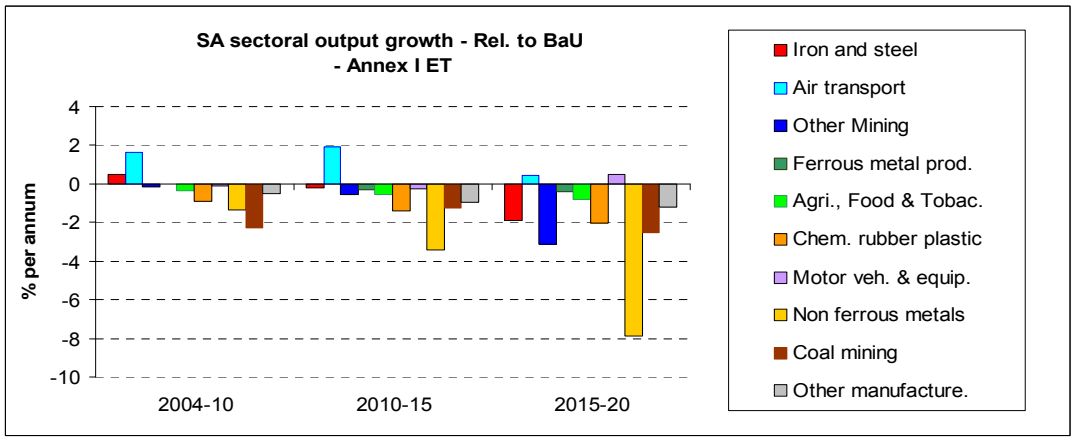
Figure 3.15: Change in export for energy intensive sectors – relative to BaU (average % per annum)

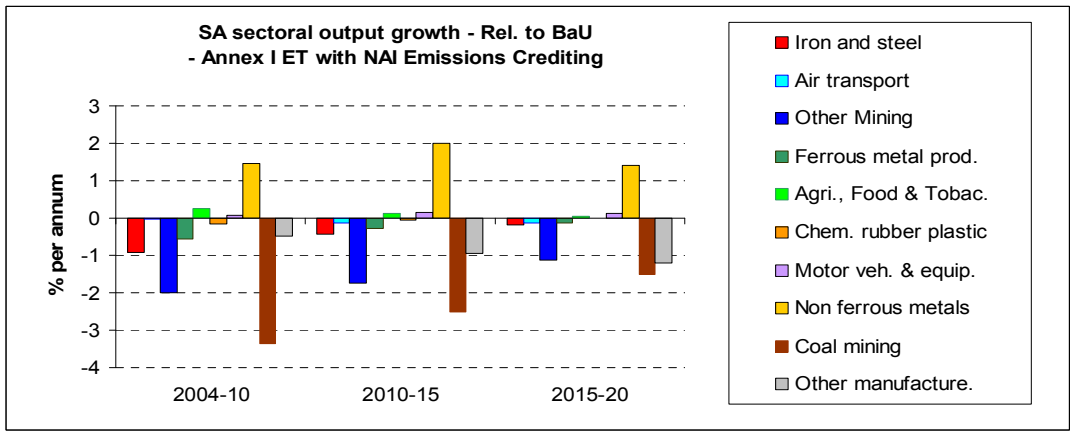
Domestic microeconomic impacts on South Africa

Figure 3.16 looks at the domestic growth rates of sectors in the South African economy for Scenario 2 (under the same underlying assumptions about GDP and population growth as in Scenario 1). Comparing Figure 3.16 with Figure 3.13, again, it can be seen that changing the severity of Annex I emissions reduction target from -25% to -40% below 1990 level does not significantly affect the patterns of results, even though the magnitudes can change. Only one sector shows high sensitivity to the emissions reduction target, and that is 'Non-ferrous metal'. The negative impacts (in Scenario 1) of –about -1 % to -3% p.a. (relative to BaU scenario) for the cases of 'No ET' and 'Annex I ET' has now increased to around -1% to -8% p.a.) for the cases of 'No ET' and 'Annex I ET'. Remarkably again, only in the case of 'Annex I ET with NAI no-lose crediting' that the magnitude of the gains for 'Non-ferrous metals' seems to have remained relatively unchanged: from 1.2% – 1.5% (Scenario 1C) to just 1.5% – 2% (Scenario 2C).

Figure 3.16: Sectoral output growth in South Africa – Scenario 2 relative to BaU (average % per annum)







Conclusions

Overall, the results of Scenario 2 help to establish an important observation, and that is, although the magnitudes of the impacts of response measures on South Africa may change with the magnitude of the emissions reduction target by Annex I regions (as expected), the patterns of the impacts seem robust and do not change significantly with changing emissions reduction target. There is however a significant shift in the patterns of impacts if there is a change in emissions trading regime from 'Annex I ET' to 'Annex I ET *with* NAI no-lose crediting'.

Throughout both Scenario 1 and Scenario 2 it has been observed that (i) 'Coal mining' always lose irrespective of ET regime, the losses[40] are greater if there is greater co-operation in ET (Scenarios 1B and 1C). This is to be expected because greater co-operation in ET implies greater and wider efforts at CO_2 emissions reduction, hence the use of coal will fall world wide and exports of coal from South Africa will also fall, (ii) In addition to 'Coal mining', other sectors may also lose but unlike 'Coal mining', here the losses (or even gains) depends on whether there is 'Annex I ET' or 'Annex I ET *with* NAI no-lose crediting'. The reason for this can be given as follows: When Annex I regions impose emissions reduction targets but *without participation of NAI regions*, assuming the 'worst case'[41] scenario when developing countries do not impose any climate response measures of their own but instead just 'free ride' on developed countries' efforts, this will create a so-called 'leakage effects' which shifts production of energy-intensive products such as Minerals and mining, Chemicals, Metal products (ferrous and non-ferrous), and Air transport (see Table 3.1) from developed countries to developing countries. This will create two different effects on South Africa. Firstly, the '*net* income effect' which can stimulate (or decrease)[42] production and exports of these energy-intensive and trade-exposed (EITE) products from South Africa to Annex I countries. The second ('regional competition' or 'regional substitution') effects will determine if a country such as South Africa can benefit more or less from a shift of production activities[43] from Annex I to developing countries as compared to another developing country such as China. If the 'net income effect' is positive and dominates, then South Africa will benefit from 'Annex I ET' (or 'No ET'). This is the cases of 'Iron and steel', 'Air transport', and 'Other mining'. If the 'net income effect' is negative or if the 'substitution/competition' effect dominates, then South Africa can lose. This is the cases of all other EITE sectors except the three mentioned above.

When there is participation of NAI countries in the overall emissions reduction efforts as in the case of 'Annex I ET with NAI no-lose crediting', there is an additional 'income effect' for the world as a whole because of the increased efficiency of climate response measures. This will add to the 'net income effect' considered above. We can call this the 'world income effect' (on South Africa) which represents the strength of the overall world demand for EITE products coming from South Africa as a result of the climate response measures *with* 'Annex I ET and NAI no-lose crediting'. If this world income effect is stronger than regional competition effects, then South Africa can gain in exports. This is the cases of all EITE sectors except 'Coal mining', 'Iron and steel', and 'Other mining' (see Figures 3.10 and 3.14).

---

40 The 'losses' here are defined in terms of *export* losses relative to the BaU Scenario. This is also to be distinguished from domestic production losses (or gains) which mostly follows the pattern of export losses but in some cases (such as 'other mining') can be different. Compare Figure 3.10 with 3.13, or 3.15 with 3.16.

41 This 'worst case' scenario is unrealistic because in reality developing countries will suffer from climate change and hence will impose some climate response measures of their own even if not obliged to and developed countries will also impose measures to combat 'leakage effects' such as import tariff adjustment or export subsidy to take account of different emissions intensities of traded goods sourced from different regions even if these measures are not easy to undertake. The 'worst case scenario' therefore serves to highlight only the potential impacts. Future studies need to undertake a more detailed analysis of the actual *likely* impacts when developing countries' response measures and developed countries 'border adjustment' measures are also taken into account.

42 There are two different 'income effects' impacting on South Africa: one (positive) which comes from the shifting of energy-intensive production activities from Annex I countries to (developing countries including) South Africa and the other income effect which comes from the reduced demand for these products within Annex I countries themselves due to climate response measures. If the former is stronger, then net income effect will be positive for South Africa, but if the second (negative) income effect is stronger, then net income effect for South African exports will also be negative and hence decreases export from South Africa rather than stimulates it.

43 i.e. assuming the 'net income' effect is positive.

4. Further research

This work has confirmed some results of previous studies, while extending it in relation to energy-intensive and trade-intensive sectors and examination of scenarios related to emissions trading. This work was conducted with the analytical rigour possible within a tight time-frame for the modelling and delivery of a report, prior to the negotiations in Copenhagen in December 2009. The research process and its results suggest four areas in which the technical analysis could be further improved and one scenario which would be informed by the outcome of negotiations.

1. Full alignment of sectors in terms of energy-intensive and trade-exposed sectors of the economy (SASID, SSA, Energy Balances and IEA). One of the main challenges posed when doing the energy-intensive analysis was that Statistics South Africa (SSA) classify non-ferrous metals in the same group as basic metals (i.e. iron and steel) in their GDP data. Thus assessing the energy-intensity of iron and steel as separate from non-ferrous products was not possible. In addition, although shown to be of a lower energy-intensity, paper and wood products are similarly combined into one category in the SSA data.

2. The impacts on agriculture and tourism deserve particular attention. More specifically, the issue of carbon footprinting which implies products produced from developing countries and bought by developed countries, involve many intermediate production processes which may impact upon (as well as be impacted upon by) climate measures and therefore should be taken into account. For example, carbon footprint labelling schemes and the impact this has on the competitiveness of the agricultural sector. In this report agriculture was not seen to be of high carbon intensity but its dependence on the use of transport supports acknowledgement of this sector in terms of the indirect impact of response measures to climate change by Annex I countries on exports from this sector. Also, there is the issue of international tourism[44] which affects production and consumption activities of both developed and developing countries jointly. This study found that South Africa will benefit from emissions, in that the negative impacts of climate change (in the BaU scenario) are to some degree attenuated, thus the reduction in foreign tourism arrivals will be less than in the BaU scenario.

3. Appropriate tourism data – a major challenge was acquiring the information on tourist expenditures in various sectors and how the total number of tourists may change as a result of climate response measures. This will then be used to define an 'International tourism' sector more accurately and model their changes over different periods. The Hamburg Tourism Model was one source of information on the total number of International tourists, but one also needs to know how International tourist expenditures may differ from domestic tourism expenditure to translate this into impact on total expenditure in the 'tourism sectors' (defined in Table 3.2).

4. Depending on the outcome of negotiations in Copenhagen, an extension of the work on NAI no-lose crediting could be to consider domestic emissions trading in NAI countries. This depends in the first instance on the politics of negotiations and the level of interest in exploring innovative carbon trading mechanisms. Such analysis would, however, not necessarily have to assume a 'hard' cap on emissions, i.e. reductions or limits in absolute terms. Emissions trading could be conceived in relation to intensity goals, which would require a relative reduction or deviation below baseline. An indication would be needed from the South African government on whether such analysis would be of interest.

5. Further research should address domestic policy measures to address the vulnerability of energy-intensive and trade-exposed sectors to response measures by developed countries. Such measures should be designed in the overall context of climate policy, enabling these sectors to contribute to action on climate change. An assessment of the range of options to promote energy-efficiency in energy-intensive sectors to reduce their energy demand, for example, energy efficiency improvements through demand-side management or technological advancements. We note that impacts of climate response measures on energy-intensive industries in a NAI country such as South Africa can be ambiguous. On the one hand, these industries may benefit rather than suffer from climate response measures in terms of lower

[44] One of the challenges faced when trying to model the impact of climate change responses specifically on tourism was the lack of model inputs. As a consequence, this is not dealt with at this stage.

energy prices due to reduced world demand (relative to BaU Scenario) and hence will not try to improve energy-efficiency on their own initiative. Furthermore, if there is any potential for 'leakage effect', this will also benefit rather than harm these industries and therefore, the incentive for improvement on energy-efficiency is lacking in these circumstances. Therefore, there is a need for additional measures to promote energy-efficiency in these industries either through technological standard (in conjunction with some incentive such as investment subsidy) or some form of energy/emissions tax. To protect the energy-intensive but trade-exposed sectors, Simmonds (1995), Clark (2000) and Liang *et al* (2007: 311) show that one way is to 'combine the tax exemption for energy- and trade-intensive sectors with the reimbursement of tax revenue to the un-exempted sectors'. The one way in which this option could be explored is through a national level CGE modelling exercise whereby a carbon tax on certain industries could be tested to assess the economy-wide implications thereof. This could be taken further into the international context to determine the impact such a tax could have on the competitiveness of those industries.

5. Conclusions and recommendations

This research confirms findings of previous studies (see Section 1.3), that the impacts of response measures may imply losses of exports in some sectors, but also possibly gains in other sectors. The present report has provided a more specific identification of energy-intensive and trade-intensive sectors – and those that are both energy and trade intensive. We have also examined variations related to scenarios with and without emission trading among Annex I countries, and extended this to the consideration of a no-lose crediting approach for NAI countries.

This study revealed that the five top energy-intensive and trade-exposed sectors in South Africa are:

1. basic iron and steel;
2. non-ferrous metals;
3. chemicals and petrochemical products;
4. mining and quarrying (including coal);
5. machineries and some other manufactures (such as food products, as well as transport vehicles and equipment.

Unsurprisingly these are similar sectors to those identified in other countries facing the same policy dilemmas. Transport as a service sector is highly energy-intensive. However, often transport (and trade) is considered only as a 'margin', i.e. as a means to facilitate production and exchange, hence it may not feature directly as a single 'sector'. Air transport is also a component of international tourism which is an important trade-related or export sector (see Section 3 below). Hence the list of energy-intensive trade-intensive sectors may also include transport:

6. transport services including air transport.

In general, with the climate negotiations on the future of the climate regime post-2012, the implication for energy-intensive and trade-exposed sectors of the economy needs to be clearly understood.

The scenarios considered include two reduction scenarios for Annex I – 25% (Scenario 1) and 40% (Scenario 2) below 1990 levels by 2020. Each of these two Annex I mitigation scenarios considers three different variants, distinguished by their assumptions about emission trading: (a) no emissions trading, (b) trade only among Annex I countries, and (c) access to carbon markets for NAI countries on a no-lose crediting basis. The 'No emissions trade' scenario is not considered likely (given existing and planned trading schemes), but provides a benchmark against which marginal abatement costs of other variants can be assessed. 'Annex I emissions trade' keeps the situation as with the Kyoto Protocol, with trading limited to developed countries, but not extended to developing countries. The third variant considers a situation (as currently under negotiation for the period after 2012) in which NAI countries could trade on a 'no-lose crediting' basis.

The underlying concern for EITE sectors is the potential for leakage, that is for industries to be located in areas with no or lower constraints on emissions. The evidence on the impacts on competitiveness, as assessed by the Intergovernmental Panel on Climate Change Fourth Assessment Report, was limited (IPCC 2007). In this study, we find that leakage can be a significant concern, with rates rising from 12% in 2010 to 14% in 2020 for a 25% reduction below 1990 levels for Annex I countries which increases to 12% to 16% respectively for the 40% reduction scenario. However, we also note that the measurement of leakage rate depends crucially on the assumptions made about the reactions of both developed and developing countries to the changed economic conditions after response measures have been implemented (in developed countries only). The leakage rates above derive from the 'worst case' scenario with developing countries taking no action on climate change and developed countries not moving to protect industries adversely affected by climate response measures. The 'worst case' leakage rate is therefore used only to serve the purpose of highlighting the potential gains from countries co-operating to combat climate change and avoiding any counterproductive 'free riding' effects. This co-operative situation is represented by the Scenario 'C': 'Annex I ET with NAI no-lose crediting' in our simulations.

The overall results of modelling the impacts of response measures suggest that, nationally, losses due to exports (coal and other) are off-set by gains in exports of energy-intensive and trade-intensive sectors. However, this occurs only in a situation with emissions trading extended *beyond Annex I*, on

the basis of no-lose crediting for NAI. In the case of the 'No ET' scenario and the 'Annex I ET' scenario, South Africa can expect real production losses, essentially because global competition for export of energy-intensive goods to Annex I countries intensifies on the back of falling fossil fuel prices (due to falling world demand) which may end up allowing some NAI regions such as China to gain from the competition, but resulting in losses for others such as South Africa. The overall losses, however, can be turned into potential gains if NAI regions are allowed to participate in a global ETS on a 'no-lose' basis.

In terms of potential gains from emissions crediting this study found that South Africa might earn $285 billion in 2010 (for the 25% no-lose NAI mitigation scenario which rises to $470 million for the 40% scenario), $121 million in 2015 ($187m) and $64 million in 2020 ($68m). These potential earnings should be understood in the context of massive gains from emissions trade by Annex I, for example, the US would save $4288 million in 2020 in the 40% scenario.

A summary of the analysis can be described briefly in terms of winners and losers as follows:

Losers:

- 'Coal mining' irrespective of emissions trading regimes, due to reduced worldwide demand in all scenarios relative to BaU (around -1.5 to -2% per annum in 'no ET' and 'Annex I ET' Scenarios and around -2.5 to -3% in 'Annex I ET with NAI no-lose crediting Scenario). More specifically the figures above show (as well as those in Table 3.10 later) that across all three scenarios assessed (No ET, Annex I ET and Annex I ET & no-lose crediting) the coal sector stands to lose in terms of exports. However, in the last scenario, with no-lose crediting, the magnitude of this negative impact on the coal sector is significantly smaller, dropping from 5.4% in 'no ET' to 0.3% in 'no-lose crediting'.
- Other EITE sectors benefit from no-lose grading, but show some losses otherwise. There sectors are ferrous metals; agriculture, food and tobacco; chemical rubber plastic; motor vehicle and equipment; non ferrous metals; other manufacture; international tourism. This is due to a combination of reduced demand (income effect) in Annex I countries and strong competition from other NAI countries in the supply of these goods to Annex I countries. 'Air transport' escapes from losses because of the benefit of reduced fuel costs due to reduced world demand for fuels (relative to BaU Scenario). 'Iron and steel' and 'Other mining' avoid reduction due to leakage effects to South Africa despite competition from other NAI countries.

Winners:

- 'Iron and steel', 'Other mining' and 'Air transport' in 'No ET' and 'Annex I ET' Scenarios. The positive impact on 'Air transport' in South Africa is primarily due to reduced fuel costs due to reduced world demand for fuels (relative to BaU). The positive impacts on 'Iron and steel' and 'Other mining' in South Africa is partly due to potential 'leakage effects'.
- Most EITE sectors can turn losses into gains with 'no-lose trading' or even just 'Annex I trading' – except 'Coal mining', 'Iron and steel', and 'Other mining'. The potential losses outweighed by the positive income effect from improved efficiency in this ET regime, particularly if the sectors have access to the carbon markets directly.
- 'International tourism' – as with most sectors – shows positive impacts when there is 'Annex I ET with NAI no-lose crediting', but reports losses when there is no NAI no-lose crediting. This is (at least in part) due to the way this sector is created in this analysis.[45] Firstly, 'International tourism' shows negative impacts in 'No ET' and 'Annex I ET' scenarios because of the negative

[45] In this study we assume the expenditure level of 'International tourists' takes up a fixed proportion of the total expenditure level in sectors such as 'Other market services', 'Recreational and other services', 'Trade and transport' (see Table 3.2). This means when the total expenditure in these sectors changes (as a result of the climate response measures) we implicitly assume that the expenditure level by international tourists in these sectors also change by the same proportion. This implies either that the expenditure level per tourist remain the same but the total number of tourists change or the number of tourists remain the same but their expenditure level per tourist has changed. Future studies may want to determine either or both of these two factors (in some exogenous simulations) to determine more accurately the changes in the proportion of international tourism expenditure level in these sectors over different periods rather than assuming them to remain unchanged, as assumed in this study.

impacts on the 'Trade and other transport (except air transport)' and 'Other market services' sectors despite positive impacts on Air transport sector. Only in the 'Annex I with NAI no-lose crediting' scenario that this is turned around.

The findings suggest that policy-makers might wish to consider the following:

- Negative impacts on the coal exports sector needs to be considered for further studies.
- The mixed impacts on a range of sectors, including iron and steel, non-ferrous metals, chemicals, machinery and transport equipment, due to the differences inherent in different ET regimes, need to be considered for climate change considerations and negotiations, as well as for domestic industry policies. More specifically:
    - In terms of international climate policy negotiations. In particular, the potential gains (for South Africa as well as other developing countries) from an ET regime which allows for crediting for developing countries on a 'no-lose' basis. These potential gains are reflected in the results of this study and implies this is a promising policy approach. This approach therefore can be supported at the international negotiation level; however, at the same time, further research needs to be conducted at the South African level to help identify more specifically the gains for South Africa and policies needed to facilitate these gains.
        - Research is needed to understand how this ET approach would work in practice in South Africa and to what extent it would help reinforce or is in conflict with domestic policies aimed at energy savings in South Africa to move towards a low carbon economy.
        - The impacts of industrial energy efficiency policies in South Africa and impacts of international ET regimes on South African sectors have domestic budgetary implications such as profitability and employment as well as environmental implications such as lower GHG emissions and future sustainable development of the country (Howells Laitner, 2005). The key question is how to reconcile or combine these two consequencess.
    - In terms of domestic climate policy on mitigation, the identified energy-intensive and trade-intensive sectors would either require a structured regulatory approach (e.g. benchmarks for emissions intensity in relation to their greater exposure), or incentives. Incentives could be domestically defined, e.g. through incentives to improve energy efficiency (and thus reduce intensity) or incentives in industrial policy for trade-exposed sectors.
- The impacts on agriculture and tourism deserve particular attention. Specific areas of focus for further work are suggested in section 5.

In general, previous studies have found the sectoral impacts of response measures to be negative. This report however shows that not all impacts will be negative, in fact some sectors will experience a positive gain from the implementation of response measures to climate change by Annex I countries. South African policy-makers must thus be aware of not only the sectoral gains and losses but more importantly the magnitude of these losses, and the degree to which they can be balanced by gains. Ultimately, trade and climate policy-makers need to be prepared to deal with the energy-intensive and trade-exposed sectors identified in this report.

References

Babiker, M; Reilly, J.M and Jacoby, H.D. 2000. 'The Kyoto Protocol and developing countries'. *Energy Policy,* 28: 525 – 536.

Burniaux, J. -M., Truong, T. P. 2002. 'GTAP-E: An Energy-Environmental Version of the GTAP Model.' GTAP Technical Paper No. 16 (revised), Center for Global Trade Analysis, Purdue University, West Lafayette, Indiana, USA, https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=923

Clark, A. 2000. 'Demand-side management in restructured electricity industries: An international review'. Energy & Development Research Centre, University of Cape Town.

Consult 101 in association with Environmental Counsel cc and The Industrial Development Corporation of South Africa. 'How will the responses of the developed countries to the United Nations' Framework Convention on Climate Change affect South Africa?'. *Submitted to the Fund of Research into Industrial Development, Growth and Equity (FRIDGE).*

DME (Department of Minerals and Energy) 2003. Integrated energy plan for the Republic of South Africa. Pretoria. www.dme.gov.za.

DME (Department of Minerals and Energy). 2006. 'Digest of South African Energy Statistics'. *Directorate: Energy Planning and Development.*

DTI (Department of Trade and Industry) 2005. Developmental Electricity Pricing Programme. Pretoria. Accessed on 24 November 2009 at: http://www.dti.gov.za/publications/2006_11_17_DEPP.pdf.

Edwards, L, Cassim, R & van Seventer, D, 2010: Trade Policy in South Africa in Aron, J, Kahn, B & Kingdon, G, *South African Economic Policy Under Democracy*, Oxford University Press.

Fine, B and Rustomjee, Z. 1996. 'The Political Economy of South Africa: From Minerals-Energy Complex to Industrialisation'. *Witwatersrand University Press,* Johannesburg.

Hamilton, J.M. Maddison, D.J. and Tol, R.S.J.2005. 'Climate change and international tourism: a simulation study'. *Global Environmental Change,* 15 (3): 253 – 266. Accessed at: http://fnu.zmaw.de/HTM.5681.0.html

Hanoch, G., (1971). 'CRESH Production Functions,' *Econometrica*, 39(5):695-712

High Level Group Competitiveness, Energy and Environment. 'Ad hoc Group 3 Competitiveness of and access to cost-effective energy inputs for energy intensive industries: Chairman Issues Paper'. Accessed on 4 November 2009 at: http://ec.europa.eu/enterprise/policies/sustainable-business/files/environment/hlg/docs/c_i_p_4_en.pdf

Howells, M and Laitner, J.A. 'Skip'.2005. 'Industrial Efficiency as an Economic Development Strategy for South Africa.' *Summer Study on Energy Efficiency in Industry*, Energy Research Centre, University of Cape Town.

Hughes, A; Howells, M and Kenny, A. 2002. 'Baseline Study – Energy Efficiency'. *Energy Research Institute,* University of Cape Town. Report No P-54126.

Ianchovichina, E. and McDougall, R. 2000. 'Theoretical Structure of Dynamic GTAP' GTAP Technical Paper No. 17, Center for Global Trade Analysis, Purdue University, West Lafayette, Indiana, USA. .https://www.gtap.agecon.purdue.edu/resources/download/160.pdf.

International Atomic Energy Agency; United Nations Department of Economic and Social Affairs; International Energy Agency; Eurostat and European Environment Agency. 2005. 'Energy Indicators for Sustainable Development: Guidelines and Methodologies'. *International Atomic Energy Agency,* Vienna.

International Energy Agency. 2008. 'World Energy Outlook 2008'. OECD/IEA, France.

IPCC, 1996: The Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press,Cambridge.

IPCC, 2007. 'Climate Change 2007: Synthesis Report'. *An Assessment of the Intergovernmental Panel on Climate Change.* Accessed at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

Liang, Q.M; Fan, Y and Wei, Y. 2007. 'Carbon taxation policy in China: How to protect energy- and trade-intensive sectors?'. *Journal of Policy Modeling,* 29: 311-333.

Mongia, P; Schumacher, K and Sathaye, J. 2001. 'Policy reforms and productivity growth in India's energy intensive industries'. *Energy Policy,* 29: 715 – 724.

Narayanan B.G. and Walmsley, T.L (Editors) 2008. *Global Trade, Assistance, and Production: The GTAP 7 Data Base*, Center for Global Trade Analysis, Purdue University. https://www.gtap.agecon.purdue.edu/databases/v7/v7_doco.asp

Neuhoff, K 2009. Tackling carbon: How to price carbon for climate policy Cambridge, University of Cambridge. http://www.climatestrategies.org/our-reports/category/1/28.html last accessed 11 September 2009.

Schmidt, J; Helme, N; Lee, J and Houdashelt, M. 2008. 'Sector-based approach to the post-2012 climate change policy architecture'. *Climate Policy,* 8: 494-515.

Simmonds, G. 1995. 'International energy efficiency experience: Lessons for South Africa'. Energy & Development Research Centre, University of Cape Town.

South African Reserve Bank Quarterly Bulletin, June 2009. Statistics South Africa, 1993*:* South Africa Standardised Industry Classification, Accessed at: http://www.statssa.gov.za/additional_services/sic/sic.htm

SSA [Statistics South Africa] 2008. Third Quarter (November 2008). GDP – Key Indicators. Table B. Accessed at:http://www.statssa.gov.za/

SSA [Statistics South Africa] 2005. Third Quarter (November 2008). Draft Tourism Satellite Accounts. Accessed at: http://www.statssa.gov.za/publications/D04057/D040572005.pdf

Truong T.P., Kemfert, C., and Burniaux, J. -M. 2007. 'GTAP-E: An Energy-Environmental Version of the GTAP Model with Emission Trading.' German Institute for Economic Research (DIW) Discussion Paper 668, February, Berlin, Germany. http://www.diw.de/documents/publikationen/73/diw_01.c.55787.de/dp668.pdf

van Seventer, D.E.N; Truong, T.P and Goldblatt, M. 2000. 'The Potential impact of International Protocols and Agreements regarding global climate change on South African Coal Exports and Hence, on Eskom'. *Unpublished Report for Eskom.*

Wainwright, D, 2002, Testimony besfore the Senate Finance Committee on Ongoing U.S. Trade Negotiations, February 6, http://finance.senate.gov/hearings/testimony/020602dwtest.pdf.

Winkler, H; Davidson, O; Kenny, A, Prasad, G; Nkomo, J; Sparks, D; Howells, M; Alfstad, T; Mwakasonda, S; Cowan, B and Visagie, E. 2006. 'Energy Policies for Sustainable development in South Africa: Options for the future'. *Energy Research Centre,* University of Cape Town.

Winkler, H & Zipplies, R 2009a. Taking on a fair share: The goliath of Africa's emissions. R Zipplies (Ed). *Bending the curve: Your guide to tackling climate change in South Africa*. Cape Town, Africa Geographic 108-119.

Winkler, H and Marquard, A. 2009b. 'Changing development paths: From an energy-intensive to low-carbon economy in South Africa'. *Climate and Development*. 1(2009): 47 – 65.

Winkler, H; Marquard, A; Tyler, E; Visser, M and Brick, K. 2009c. 'Economics of climate change: Context and concepts related to mitigation'. *Energy Research Centre*, University of Cape Town. Accessed on 1 November 2009 at: http://www.erc.uct.ac.za/Research/publications/09Winkler-etal-%20Economics_Climate_change.pdf

Appendix 1: Additional input

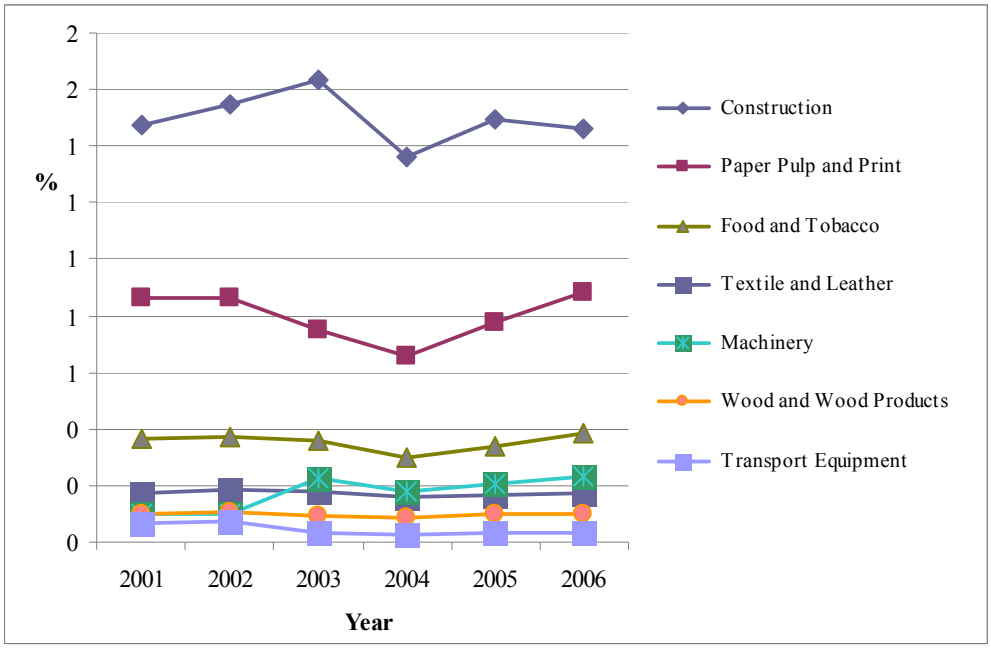


Figure A.1: Trends in the other main energy consuming industrial sectors between 2001 and 2006

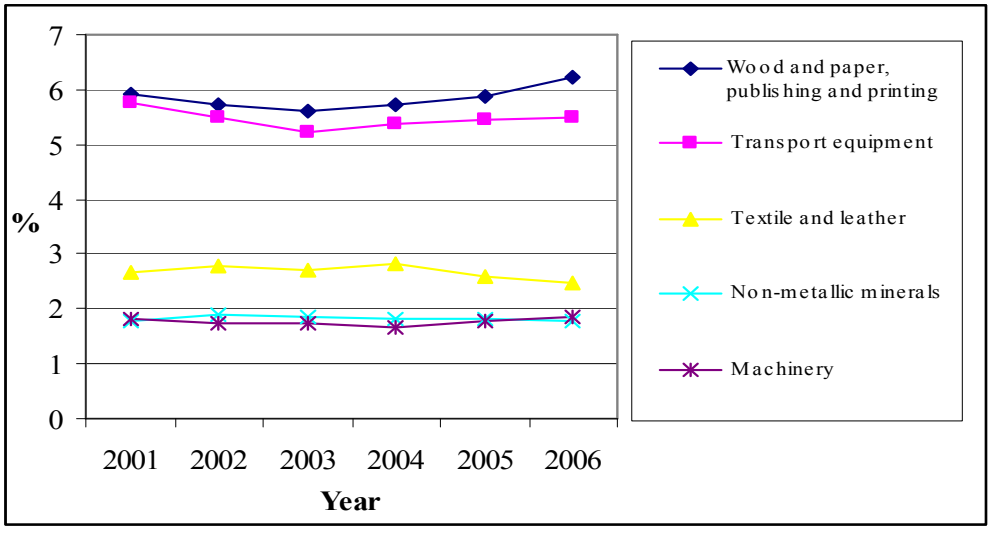


Figure A.2: Trends in GDP across the other main industrial sectors between 2001 and 2006

Appendix 2: Detail on GTAP-E database and its aggregation in this study

The Global Trade Analysis Project database and associated models

In the modelling part of the project, we make use of a special purpose global economic and trade data set compiled by the Global Trade Analysis Project (GTAP), a companion energy volume data set and CO_2 emission data. Although there are many modelling frameworks that can be used to evaluate the likely impact of carbon reduction emission, we have selected the GTAP framework because it identifies the South African economy as a single region and also because the suite of GTAP models (including GTAP-E) are widely used and publicly available.[46].

The economic and trade part of the database (version 7) identifies 113 regions and 57 commodities/sectors (see Narayanan & Walmsley 2008). In addition to intermediate demand and international trade, final demand and primary inputs, or factors of production are accounted for. Final demand is represented in its most aggregate form, i.e. by means of a single household, a single government and a single bundle of investment demand. Endowments (or factors of production) consist of four categories: labour, land, capital, and natural resources. GTAP distinguishes between skilled and unskilled labour which is of particular interest to South Africa, where unemployment amongst unskilled labour is considered to be very high compared to skilled labour. Anecdotal evidence even suggests that the latter is close to being fully employed. We note however, that as is standard in a computable general equilibrium (CGE) model approach such as GTAP, labour demand and supply (whether skilled or unskilled) are mostly assumed to be equalised (i.e. markets clear). Thus, to translate these variables into actual employment and unemployment rates requires additional information and assumptions on participation rates (in addition to population growth and distribution). Therefore, results from a 'policy analysis' using CGE model should be distinguished from the usual forecast analysis, unless the model is specifically adapted for this purpose (such as the case with MONASH model (http://www.monash.edu.au/policy/)).

With this database GTAP has developed a standard neoclassical trade modelling framework that simulates impacts and interactions amongst these institutions based on the principle of global general equilibrium. General equilibrium modelling frameworks have a number of suitable characteristics that allow, according to Arndt & Lewis (2000)[47] for the examination of a range of economic policy issues including the following:

- The simulation of the functioning of a market economy, including markets for labour, capital and commodities to provide a useful perspective on how changes in economic conditions will likely be mediated through prices and markets.
- Unlike many other partial equilibrium or aggregate macro approaches, they are based on a consistent and balanced set of economy-wide accounts (which in our case is a string of simplified regional Input-Output tables). This requires that behavioural and accounting constraints such as budget constraints and balance of payment equilibrium are maintained, which serve as an important check on the 'reasonability' of the outcomes.
- Because they can be fairly disaggregated, general equilibrium models offer an economic 'simulation laboratory' with which we can examine how different factors and channels of impacts will affect the performance and structure of the economies involved, how they will interact, and which are quantitatively the most important.

An important feature of this class of models is that they allow for various degrees of substitution to take place at various points in the economic system. For example, these models usually allow for the substitution of labour for capital in reaction to changes in the wage rate. Another example is the demand for goods and services which is governed by imperfect substitution between domestically produced and imported supply. If the price of the domestically produced good rises, say, as a result of an increase in an import tax, demand is supposed to shift to some degree towards imported goods.

---

46 Alternative models like the MIT EPPA model (which also uses the GTAP database) – see Paltsev *et al.* (2005) - is not publicly available.

47 Arndt C, & Lewis J, *The Macro Implications of HIV/AIDS in South Africa, a Preliminary Assessment*, Paper presented at the TIPS Annual Forum, September 2000.

GTAP-E model and database

In order to tackle some of the interactions between the environment and global trade, the economic database of GTAP has been extended with energy volume data and carbon ($C0_2$) emission data. With the extended database, it is then possible to allow for further possibilities of substitution, i.e., those amongst forms of energy (coal, gas and petroleum) and those between energy and capital. The former may be brought about by imposing a uniform tax on carbon emissions or an exogenous increase in the price of CO_2 and since the various forms of energy produce different levels of carbon per unit producers, which are assumed to be cost minimisers, will shift their demand to forms of energy that produce less carbon. Similarly, producers are allowed, as is known to happen in economic reality, to switch to the use of more capital with the intention to save energy. The substitution between alternative forms of energy inputs in production and consumption activities in the GTAP model is specified in a special version called GTAP-E version and has been used to study the issues of energy-substitution, environmental and climate policy studies (Burniaux and Truong, 2002; Truong *et al*. 2007).[48]

The GTAP-E model, in its standard form, is still a comparative static general equilibrium model, i.e. each simulation assumes the economies traverse from one equilibrium position to another, and therefore, only the final equilibrium end points are considered but not the transitional path.[49] Furthermore, because each period is considered to be 'self-contained' (necessary for the solution of the general equilibrium outcome), this means there is no carry on of expectation from one period to the next and no inter-temporal optimisation between the periods. This means the model is simply solved for each simulation period of simulation and the results are then used to update the database for the next period simulation. This is called 'recursive dynamic' approach is to be distinguished from models which allow for intertemporal optimisation and 'forward looking' expectation which can be regarded as 'truly' dynamic. To date, due to computational as well as theoretical complexities, truly dynamic models exist only in highly aggregate form, typically with only a single or a few sectors of the economy, and therefore, are less suitable for policy analysis at the sectoral level.

The GTAP-E model allows for capital stock to be read at the beginning of each period and updated at the end of the period. To make the model recursive dynamic, the growth of capital during each period needs to be linked to an investment decision (and depreciation of the capital stock) during each period. It is the theory behind the investment decision that distinguishes between different 'types' of dynamism in a Computable General Equilibrium (CGE) model, and this can range from highly sophisticated setups of adaptive expectation and 'error correction process'[50] to simpler theory of investment decision based on some hypothesis about the long run or 'normal' rate of return.[51] With respect to labour (employment), the dynamics in the employment of this factor can also be determined by various theories about how labour demand and supply are linked to real wages and population growth. Finally, other factors such as land and natural resources can also be made 'dynamic' by employing some theories about land and natural resource scarcity, etc.

In the absence of these sophisticated theories, however, a simpler approach is to rely on 'exogenous' projection of the growth of these factors. In our case, because of the long time frame and the difficulty of maintaining some hypothesis or assumptions for such a long period of time, we have chosen to adopt a simpler approach. It is assumed that the rates of growth of GDP and population will be 'consistent' with some other studies (such as the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios). Once the rates of growth of GDP are 'determined', the growth of primary factors cannot be left entirely 'exogenous' but must be related to these assumed GDP growth rates. For example, we can imagine the whole economy as an 'aggregate' sector (as most aggregate models of economic growth would) and therefore, GDP is just an 'output'

---

48 There are two versions of the GTAP-E model, one maintained by Truong (Truong *et al*. 2007) and one maintained by the GTAP centre (Burniaux and Truong, 2002, McDougall and Golub, 2009), both are publicly available at the GTAP website: https://www.gtap.agecon.purdue.edu/. Latest research relating to the use of the GTAP-E model includes a study on the set of substitution parameters used in the GTAP-E model, and this is documented in Beckman *et al.* (2009).

49 If the time period is sufficiently long (at least 5 years as in this study), this can be considered to be a reasonable assumption.

50 See for example Ianchovichina and McDougall (2000).

51 See, for example, investment decision in the ORANI-GD model, http://www.monash.edu.au/policy/oranig.htm#oranigrd.

from an aggregate 'production function' which has the aggregate primary factors as inputs. The form of this aggregate production function determines the 'elasticity' of substitution between the factors of production, and therefore, their relative growth rates once the output growth has been determined.[52]

Concordance between GTAP version 7 and Quantec standardised industry databases

Table A.1 shows the concordance between GTAP v7 and Quantec standardised industry (SASID) databases. Based on this concordance, we have selected a particular sectoral aggregation which is suitable for the purpose of this study and this is shown in Table A.2. Table A.3 then shows the regional aggregation which is selected to highlight the most important trade partners with South Africa.

Table A.1: Concordance of GTAP version 7 and Quantec standardised industry databases

GTAP No.	*GTAP Code*	*GTAP Description*	*SASID No.*	*SASID Description*
1	PDR	Paddy rice	1	Agriculture, forestry & fishing
2	WHT	Wheat		
3	GRO	Cereal grains nec		
4	V_F	Vegetables, fruit, nuts		
5	OSD	Oil seeds		
6	C_B	Sugar cane, sugar beet		
7	PFB	Plant-based fibres		
8	OCR	Crops nec		
9	CTL	Bovine cattle, sheep, goats, horses		
10	OAP	Animal products nec		
11	RMK	Raw milk		
12	WOL	Wool, silk-worm cocoons		
13	FRS	Forestry		
14	FSH	Fishing		
15	COA	Coal	2	Coal mining
16	OIL	Oil	4	Other mining
17	GAS	Gas		
18	OMN	Minerals nec		
			3	Gold & uranium ore mining
19	CMT	Bovine meat products	5	Food
20	OMT	Meat products nec		
21	VOL	Vegetable oils and fats		
22	MIL	Dairy products		
23	PCR	Processed rice		
24	SGR	Sugar		
25	OFD	Food products nec		
26	B_T	Beverages & tobacco products	6	Beverages
			7	Tobacco
27	TEX	Textiles	8	Textiles

[52] Often, a constant elasticity of substitution (CES) production can be assumed, but if there are more than two factors, this function is restrictive because it does not allow for different rates of substitution between different factors. Hence we have chosen a CRESH (constant ratio of elasticity of substitution homothetic) production function instead Once the CRESH elasticities of substitution between these primary factors (including capital) are determined, the rates of growth of the factors become endogenous, and hence this is the 'special form' of 'dynamism' which has been chosen for the GTAP-E model. See Hanoch, G., (1971).

GTAP No.	*GTAP Code*	*GTAP Description*	*SASID No.*	*SASID Description*
28	WAP	Wearing apparel	9	Wearing apparel
29	LEA	Leather products	10	Leather & leather products
			11	Footwear
30	LUM	Wood products	12	Wood & wood products
31	PPP	Paper products, publishing	13	Paper & paper products
			14	Print, publish & recorded media
32	P_C	Petroleum, coal products	15	Coke & refined petroleum products
33	CRP	Chemical, rubber, plastic products	16	Basic chemicals
			17	Other chemicals & man-made fibres
			18	Rubber products
			19	Plastic products
34	NMM	Mineral products nec	20	Glass & glass products
			21	Non-metallic minerals
35	I_S	Ferrous metals	22	Basic iron & steel
36	NFM	Metals nec	23	Basic non-ferrous metals
37	FMP	Metal products	24	Metal products excl. machinery
38	MVH	Motor vehicles and parts	29	Motor vehicles, parts & accessories
39	OTN	Transport equipment nec	30	Other transport equipment
40	ELE	Electronic equipment	27	TV, radio & communication equip.
41	OME	Machinery and equipment nec	25	Machinery & equipment
			26	Electrical machinery
42	OMF	Manufactures nec	28	Professional & scientific equipment
			30	Other transport equipment
			31	Furniture
			32	Other industries
43	ELY	Electricity	33	Electricity, gas & steam
44	GDT	Gas manufacture, distribution	33	Electricity, gas & steam
45	WTR	Water	34	Water supply
46	CNS	Construction	35	Building construction
			36	Civil engineering & other construction
47	TRD	Trade	37	Wholesale & retail trade
			38	Catering & accommodation services
48	OTP	Transport nec	39	Transport & storage
49	WTP	Water transport		
50	ATP	Air transport		
51	CMN	Communication	40	Communication
52	OFI	Financial services nec	41	Finance & insurance
53	ISR	Insurance		
54	OBS	Business services nec	42	Business services
57	DWE	Dwellings		
55	ROS	Recreational and other services	44	Other community, social & personal services -profit seeking
			45	Other producers
56	OSG	Public Administration, Defence, Education, Health	43	Medical, dental & other health & veterinary services
			46	Government

Table A.2: Sectoral aggregation for this study

Aggregated Sector			*GTAP Sector*			*SASID*	
No	*Code*	*Description*	*No.*	*Code*	*Description*	*No.*	*Description*
1	COA	Coal	15	COA	Coal	2	Coal mining
2	OIL	Oil	16	OIL	Oil	4*	(part of) Other mining
3	GAS	Gas	17, 44	GAS, GDT	Gas, gas manufacture and distribution	33*	(part of) Electricity, gas & steam
4	P_C	Refined Products	32	P_C	Petroleum, coal products	15	Coke & refined petroleum products
5	ELY	Electricity	43	ELY	Electricity	33*	(part of) Electricity, gas & steam
6	AFB T	Agriculture, forestry, fishing, food beverages and tobacco	1-14, 19-26,	PDR-FSH, CMT-B_T,	Paddy rice – fishing, bovine meat products – beverages and tobacco products	1, 5-7	Agriculture, forestry, fishing, food beverages, tobacco
7	OMN	Minerals nec	18	OMN	Minerals nec	3	Gold & uranium ore mining
8	PPP	Paper products, publishing	31	PPP	Paper products, publishing	13, 14	Paper & paper products, publishing & recorded media
9	CRP	Chemical, rubber, plastic products	33	CRP	Chemical, rubber, plastic products	16-19	Basic chemicals, Other chemicals, Rubber, Plastic products
10	NMM	Non metal minerals nec	34	NMM	Mineral products ne	20, 21	Glass, Non metallic minerals
11	I_S	Iron and steel	35	I_S	Ferrous metals	22	Basic iron & steel
12	NFM	Non Ferrous Metals	36	NFM	Metals nec		Non Ferrous Metals
13	FMP	Ferrous Metal Products	37	FMP	Metal products	24	Metal Products excluding. machinery
14	MVH	Motor vehicle and parts, transport equip.	38, 39	MVH, OTN –	Motor vehicle and parts, transp equip nec	29, 30	Motor vehicle, parts, transport equip.
15	OMF	Other manufacturing	27-30, 40-42	TEX-LUM, ELE-OMF	Textiles-wood products, electronic equip-manufactures nec	8-12, 25-28, 31-32	Textiles-Wood products, Machinery & equipment (elec., TV, radio, communication, professional, scientific), Furniture, Oth industries
16	ATP	Air transport	50	ATR	Air transport	39*	(part of) Transport & storage
17	TTR	Trade and transport (excl. air transport)	47-49	TRD-WTP	Trade, transport nec, water transport	37, 38*, 39	Trade, (part of) Catering & accom. services, (part of) transport & storage
18	ROS	Recreational, cultural sporting, domestic services	55	ROS	Recreational and other services	38*	(part of) Catering & accommodation services
19	OSM	Other market Services	45-46 51-54, 57	WTR, CNS, CMN-OBS, DWE	Water, Construction, Communication-business services nec, dwellings ownership	38*, 40-42, 44	Other market Services
20	OSG	Government services	56	OSG	Public admin., defence, education, health	43, 46	Government

Note: * indicates 'part of' a sector

Table A.3: Regional aggregation for this study

No	*Code*	*Description*
1	SAF	South Africa
2	USA	USA
3	DEU	Germany
4	GBR	The United Kingdom
5	NLD	The Netherlands
	FRA	France
7	ITA	Italy
8	BEL	Belgium
9	WEU	Austria, Denmark, Finland, Greece, Ireland, Luxembourg, Portugal, Spain, Sweden
10	EFTA	Norway, Iceland, Switzerland, Liechtenstein
11	RUS	Russian Federation
12	JPN	Japan
13	ANC	Australia, New Zealand, Canada
14	RoA1	Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia, Albania, Bulgaria, Belarus, Croatia, Romania, Ukraine, Rest of Eastern Europe (Republic of Moldova), Rest of Europe (Andorra,- Bosnia and Herzegovina, Faroe Islands, Gibraltar, the former Yugoslav Republic of Macedonia, Monaco, San Marino, Serbia and Montenegro), Rest of Former Soviet Union (
15	CHN	China & Hong Kong
16	IND	India
17	BAP	Brazil, Argentina, Paraguay
18	AFR	Rest of South African Customs Union (Lesotho, Namibia, Swaziland), Nigeria, Mozambique, Zimbabwe, Botswana
19	MDE	Islamic Republic of Iran, Egypt, Rest of Western Asia (
20	RoW	Rest of the World